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1975 BRISTOL BAY SOCKEYE SALMON SMOLT STUDIES

Edited by:
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ALASKA DEPARTMENT OF FISH AND GAME
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James W. Brooks
Commissioner

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1975 BRISTOL BAY SOCKEYE SALMON SMOLT STUDIES

A summary of data collected from sockeye salmon (*Oncorhynchus nerka*) smolt programs on the Kvichak, Naknek, Ugashik and Wood Rivers.

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TABLE OF CONTENTS

TABLE OF CONTENTS (Cont.).

LIST OF TABLES

LIST OF TABLES (Continued)

LIST OF FIGURES

1975 KVICHAK RIVER SOCKEYE SALMON SMOLT STUDIES

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INTRODUCTION

As part of the transition from freshwater to the marine environment, sockeye salmon smolt (Oncorhynchus nerka) emigrate from the Lake Iliamna-Lake Clark system during the months of May and June. Studies aimed at determining the age composition and relative magnitude of this outmigration have been conducted annually since 1955. Information on smolt production is in turn used for forecasting the age composition and magnitude of subsequent adult returns. Prior to 1973, the goal of the program was the determination of an index of the outmigration only. Although the index program has provided information on the dynamics of the smolt population, its reliability as a forecast tool has been variable. Commencing in 1965, attempts were made to improve the index and to develop a sampling method that would provide a total outmigration estimate. During 1969, experiments were conducted utilizing underwater sonar equipment in the belief that a total outmigration estimate could be obtained (Parker, 1973b). Sonar was again used during the 1970 field season (Russell, 1972). Improvements in the gear were made for use in 1971 and 1972 (Paulus and McCurdy, 1972; Parker, 1973a). A new sonar site was selected for the 1973 season and the program has remained in this location through 1975 (Parker, 1973b).

Operation of the original index program has continued although improvements have been made, including the use of a more modern sonar aperture counter. It is believed that eventually a relationship can be established between the index and the total outmigration estimate that will permit analysis of historical index data to obtain total outmigration estimates from past years data. Indications from the past few years show that there is a positive correlation between the index and the total outmigration estimates.

In this report, Age I and Age II are defined as smolt that have spent 1 and 2 winters, respectively, in freshwater prior to emigration.

1975 INDEX PROGRAM

Materials and Methods

Except for some modernization of the gear, the index program has remained virtually unchanged since the studies began in the middle 1950's. A 4' x 4' fyke net is fished in a standard location and at a water depth of 3.8 feet. The site is located approximately 2-1/2 miles downstream from the outlet of Lake Iliamna.

Recent improvements in the gear have included the replacement of outdated and unreliable photoelectric counters with a modern sonar aperture counter. A refined version of this gear has been in use since 1973. Briefly, the system consists of two sets of horizontally opposed transducers scanning the 4" x 18" aperture on the downstream end of a funnel attached to the fyke net. The 18° beam angle that the transducers emit provides a combined coverage of approximately 20% of the aperture. Advantages of this equipment over the older type and methods of operation are outlined in Parker (1973b).

When conditions allowed, calibrations of the equipment were conducted to determine whether the counters were functioning within acceptable limits of the theoretical five fish per count level. The average of these calibrations was used to expand the aperture counts to estimate the number of fish passing through the fyke net. Calibration procedures are described in Krasnowski (1975). Catches from the fyke net were sampled to determine mean lengths and weights and age composition of the outmigration. When catches were small data was collected from all smolt. As catch sizes increased, 2 pound sub-samples were taken. Based on the structure of the length frequency, 20 smolt were selected for age, weight and length (AWL) data and determination of an age separation point. Final age composition was calculated by weighting daily age composition estimates by the index net catch rate (fish per hour).

Results

Climatological and Hydrological Observations

Climatological and hydrological information was recorded at the Barge Island field station from May 17 through June 15 (Table 1). Both air and water temperatures were considerably below that of the previous 2 years for the same period. From May 18 through June 12, water temperatures in the river ranged from 2° C. to 6.5° C. with a mean of 3.9° C. During 13 of the 27 days when air temperatures were recorded, minimum readings fell below the freezing mark and a snowfall of over 2 inches in depth was received as late as May 22. Complete breakup of the lake ice didn't occur until June 2. Ice was encountered on the river in varied amounts almost continuously after May 24. High winds prevailed during the last week of May and contributed to the eventual breakup of the lake ice early in June.

Index Catch

Fishing commenced on the evening of May 26. Fishing was conducted during the index hours from 2200 to 0100 (AST) each night during the early part of the season. High winds and intermittent ice flow caused some loss of fishing time during the last week of May. No fish were caught until the evening of May 29 - 30 when three smolt were caught during index hours (Table 2).

The 24-hour index commenced the following day and was scheduled for every third day through the duration of the outmigration. Ice conditions worsened, becoming almost continuous after June 1. The ice not only made setting of the net impossible, but travel on the river became hazardous. Consequently, fishing was conducted any time of the day when conditions allowed. During the ensuing 5 days less than 18 hours of total fishing time was logged. After June 1 a total of 16 hours of fishing was possible during the index hours (35% of the total index hours available).

Ice began easing up on June 4 and permitted 4 hours of fishing. A 4,000 smolt catch during this time indicated a significant outmigration was in progress.

Table 1. Climatological observations, Kvichak River, May 17-June 15, 1975.

Date	Sky 0800	Sky 2000	Wind Direction-Velocity (MPH) 0800	Wind Direction-Velocity (MPH) 2000	Air Temp °C Max	Air Temp °C Min	Water Temp °C Max	Water Temp °C Min	24-Hour Precipitation (inches)	Water Level (ft.) 1/ 0800	Turbidity 0800
5/17	3	2	calm	calm	-	-	-	-	0	-	1
18	4	2	SW20	SW20	-	-2.0	3.5	3.0	T	-	1
19	4	4	NE10	NE15	4.0	-1.0	3.5	3.0	T (snow)	-	1
20	4	3	NE10	NE10	11.0	1.0	5.0	4.0	0	-	1
21	4	4	S25	SW15	11.5	2.0	3.5	3.0	T (snow)	0	1
22	4	3	S5	SW15	5.0	9.0	4.0	4.0	0.13 (snow)	0.2	1
23	4	1	S10	NE25	9.5	0.5	5.0	3.0	0	0.3	1
24	4	4	NE15	NE25	5.0	1.0	5.5	4.5	0.10	0.5	1
25	4	4	NE25	NE25	9.0	-3.5	3.0	2.5	0	0.5	1
26	2	4	NE25	NE20	10.0	1.0	4.0	3.5	0	0.5	1
27	4	4	NE20	NE10	8.5	-2.5	4.0	3.0	0	0.5	1
28	3	3	NE10	NE5	14.0	-0.5	4.0	3.5	0.08	0.5	1
29	4	4	calm	SE5	11.5	-3.5	4.0	4.0	.22	-	1
30	3	1	NE10	NE15	11.5	-3.0	5.0	4.0	0	0.7	1
31	4	4	NE10	-	11.0	1.0	4.0	4.0	0.10	0.7	1
6/1	4	2	calm	calm	8.0	-2.5	2.5	2.5	.03	-	1
2	4	3	calm	N10	18.5	-2.0	3.0	2.5	0	-	1
3	1	4	NE5	NE10	15.5	-2.5	2.5	2.5	0	-	1
4	4	4	SW15	SW10	11.0	0.0	3.0	3.0	0.38	-	1
5	4	3	NE5	N5	13.0	-3.0	4.5	3.5	0.02	-	1
6	4	3	S5	N5	14.5	2.0	4.5	4.0	0	-	1
7	2	1	NE15	E5	14.0	0.0	5.0	5.0	0	-	1
8	3	2	NE5	NE15	11.5	2.0	2.0	2.0	T	-	1
9	4	4	NE10	NE10	11.0	0.0	3.5	2.5	T	-	1
10	1	1	NE10	NE10	15.5	-2.0	6.0	6.0	0	-	1
11	1	2	NE15	NE10	16.0	2.5	6.5	4.0	0	-	1
12	3	2	N10	E15	-	-2.5	5.0	5.0	0	-	1
13	1	1	-	-	-	-	-	-	0	-	1
14	1	1	-	-	-	-	-	-	0	-	1
15	1	3	-	-	-	-	-	8.0	0	-	1

1/ Denote water level above that of base level on 5/21;

Sky codes; 1-Clear sky, cloud covering not more than 1/10.
2-Cloud covering not more than 1/2 of sky.
3-Cloud covering more than 1/2 of sky.
4-Complete overcast.

Turbidity; 1-Clear

Table 2. Kvichak River index site actual fishing time, catches, and estimated age composition of sockeye salmon smolt by day, 1975.

Date	Index Hours (2200-0100)		Non-Index Hours (1200-2200 & 0100-1200)		Total		Age Composition	
	Time	Catch	Time 1/	Catch	Time 1/	Catch	Age I	Age II
5/20-21	2.0	0	0.0	-	2.0	0		
21-22	3.0	0	0.0	-	3.0	0		
22-23	3.0	0	0.0	-	3.0	0		
23-24	3.0	0	0.0	-	3.0	0		
24-25	0.0	0	0.0	-	0.0	-		
25-26	0.0	0	0.0	-	0.0	-		
26-27	3.0	0	0.0	-	3.0	0		
27-28	1.0	0	0.0	-	1.0	0		
28-29	3.0	0	1.5	0	4.5	3		
29-30	2.5	3	0.5	0	3.0	3		100%
30-31	1.0	1	11.1	7	12.1	8		100%
5/31-6/1	0.0	-	7.7	14	7.7	14	50%	50%
1-2	2.3	164	1.1	0	3.4	164	11%	89%
2-3	0.0	-	2.7	0	2.7	0		
3-4	0.0	-	0.0	-	0.0	-		
4-5	0.5	2,920	3.5	1,082	4.0	4,002	39%	61%
5-6	2.8	38,257	15.1	114,654	17.9	152,911	57%	43%
6-7	1.5	14,829	4.1	13,693	5.6	28,522	76%	24%
7-8	0.0	-	0.3	10	0.3	10		
8-9	0.0	-	0.0	-	0.0	-		
9-10	0.0	-	0.0	-	0.0	-		
10-11	0.0	-	0.0	-	0.0	-		
11-12	0.0	-	0.0	-	0.0	-		
12-13	3.0	962	3.7	1,176	6.7	2,138	83%	17%
13-14	3.0	1,416	1.9	333	4.9	1,749	88%	12%
14-15	3.0	449	0.7	32	3.7	481	53%	47%
						$\bar{x}_W$ 2/ =	63.1%	36.9%

1/ Hours actually fished.

2/ Age composition weighted by daily catch rate/hour.

Catches during the ensuing 2 days were of peak magnitude. However, fishing was so intermittent that interpolations for missed periods were difficult to make. On June 6, 75% of the available time was fished and a linear interpolation for missed fishing time indicates a daily index in excess of 202,000. This compares with the peak index day of 183,000 in 1973. It was apparent from catches on both days that a significant part of the outmigration was occurring outside of the index hours. By this time, there had occurred a shift to an approximately equal proportion of both Age I and Age II smolt compared to that of catches of a few days earlier.

Ice flow again increased on June 6, and virtually prevented fishing of the fyke net through June 11. Three days of ice free conditions permitted fishing from June 12 through 15, but the bulk of the outmigration was over and available personnel had to be transferred to other programs. Fishing was terminated on the morning of June 15 when 449 fish were caught during 3 index hours.

The continual threat of ice also precluded the use of the aperture counter except during completely ice free periods. Several calibrations during June 5 through June 7 indicated the unit was operating properly (Table 3). Calibrations ranged from 3.7 to 7.8 with an average of 5.8 fish per count.

Table 3. Sonar aperture counter calibrations, Kvichak River index, 1975.

Date	Sonar counts	Weight of catch (lb)	Fish per pound	Total catch	Elapsed time (min)	Rate (fish/min)	Fish per count
6/5	345	41.0	31	1,271	7	182	3.7
	34	6.2	31	192	5	38	5.6
	193	31.5	32	1,008	2	504	5.2
	227	35.0	44	1,540	2	770	6.8
	223	42.0	40	1,680	2	840	7.5
6/6	25	3.0	39	117	5	23	4.7
	59	8.6	35	301	15	20	5.1
6/7	21	-	-	164	23	7	7.8

Age-Weight-Length

A total of 13 length frequencies were taken during the season in addition to 18 AWL's and a total of 281 scales were coll-cted for age determination. Since sampling was discontinuous throughout the season, age, weight and length data may not accurately reflect the actual characteristics of the outmigration.

The estimated age composition was 63% Age I and 37% Age II smolt. The mean weight by age class, using a length-weight regression formula ($W=aL^b$) and a correction term based on the variance of the mean length (Pienaar and Ricker, 1968), yielded a mean weight of 8.4 g. for Age I smolt (21-year average = 6.0 g.) and 16.4 g. for Age II smolt (21-year average = 11.1 g.). The mean length by age class for the season was 97.7 mm for Age I smolt and 121.9 mm for Age II smolt. These compare with a 21-year average of 88 millimeters and 109 millimeters for Age I and Age II smolt, respectively.

OUTMIGRATION PROGRAM

Materials and Methods

Procedures remained virtually unchanged from that of the previous 2 years. The system utilizes two Bendix biomass counting units located approximately 1/3 mile above the index site. Each unit consists of two transducer arrays suspended from a support cable that spans the entire width of the river. Cables from the individual transducers were connected to two electronic control units which were monitored from opposite sides of the river. The 1972 model electronics were operated from the west bank and the 1971 model from the east bank.

Smolt passing over the sonar gear register counts on the control units. Every 15 minutes counts are electronically totaled and recorded on paper tape. Counts are logged on a continuous 24-hour a day basis along with appropriate adjustments for "false" counts caused by boats, rain, ice, wind, malfunctioning transducers, etc. Total counts are then multiplied by the theoretical 10 fish per count to convert them into numbers of smolt. The number of smolt per foot of array for each array is calculated and expanded for the amount of unsonified river that each array is sampling. Additional information regarding count expansion techniques can be found in Parker (1973a). No satisfactory technique for field calibration of the sonar has been developed thus far, so the theoretical 10 fish per count was used for the expansion of counts.

A prototype, narrow beam side-scanning sonar was tested on the Kvichak River in 1974 and was felt to have potential for better describing the distribution, size, and rate of travel of smolt schools passing down the river. A refined version of the side scanner was used in 1975 that had a paper recording capability and a variable range feature that permitted the expansion of any desired portion of the river covered by the sonar beam.

Results

Sonar Sampling

Sonar equipment was installed by May 20, and monitoring of the system began on the following day. The abnormally late breakup of ice on the lake and generally inclement weather during the program made operation of the sonar practically impossible. The system had to be shut down entirely during extended periods of heavy ice, high winds, snow showers, and rain. Heavy ice moving down the river pulled out the array support cable and caused extensive damage to the system on June 2. Two complete arrays were salvaged from what remained and were reinstalled on June 5, after ice conditions on the river improved. Essentially no ice was present on the river through the 24-hour period from noon June 5 through noon June 6, producing the most ideal conditions encountered all season for operation of the sonar equipment. A peak magnitude outmigration was in progress at this time and the largest smolt counts were recorded during this short period. This was confirmed by the heavy catches at the index net downstream during the same day. The cable and associated sonar gear was again ripped by ice out on the afternoon of June 7. Extensive damage to the equipment and continual ice precluded further attempts at deployment of the sonar system before the end of the outmigration.

Adjusted counts for May 21-23 are not consistent with counts during subsequent days and are not supported by any index catches downriver. Since undetermined false counting conditions were suspected during this period, the use of these counts in estimating smolt outmigration is questionable. Sonar counts were at a relatively low level during the period May 24-29. Low magnitude outmigration occurring along with poor counting conditions made elimination of false counts difficult. The expansion of the adjusted counts for this period yielded approximately 3 million smolt. However, this estimate is of doubtful value.

The adjusted counts for June 5 through 7 had to be expanded for two missing arrays. The relative proportion of the outmigrations in 1973 and 1974 that occurred over each array was used to expand the 1975 data. The peak magnitude outmigration occurring June 5-6, was confirmed by the season's largest index catches.

Because of the intermittent operation of the sonar gear, no interpolations were made for missed counting time and no estimate of total outmigration is possible. Table 4 lists the hours of operation, number of counts and outmigration estimates for those periods when the sonar gear was operational.

Applying average smolt production figures (index smolt per spawner), by age class, to the parent year escapements which would produce the 1975 outmigration (1.0 million in 1972 and 0.2 million in 1973) would yield a cumulative index of 300,000 smolt and an estimated age composition of 8% Age I and 92% Age II smolt. Similarly, using the 4 years' sonar data that is available (outmigrants per spawner, by age class) would yield an outmigration of approximately 10.5 million smolt of which 10% would be Age I and 90% Age II. The difficulties encountered this season preclude direct comparison of estimates based on historical data to actual 1975 observations. However, in the limited time available for index net operation, more than 190 thousand smolt were captured. Discounting all sonar counts prior to May 29 due to questions of validity still leaves 15.6 million smolt counted during the limited operations from May 30 through June 7. Although sampling of smolt was, of necessity, limited, the observed age composition was quite different from that expected on the basis of historical data. These facts suggests that the production from the 1973 escapement was well above average.

Table 4. Kvichak River sonar counts with estimates of smolt outmigration during periods of operation, by day, 1975.1/

Date	Hours of Operation	East Bank Counts Inshore	East Bank Counts Offshore	West Bank Counts Inshore	West Bank Counts Offshore	Total Sonar Counts2/	Smolt Outmigration Estimate2/
5/21-22	13	6,959	25,113	69,633	70,650	[172,355]	[9,686,093]
22-23	22	44,457	42,520	4,218	4,613	[95,808]	[5,773,164]
23-24	24	8,451	8,763	512	452	[18,178]	[1,089,076]
24-25	1	-	-	356	253	[609]	[37,561]
25-26	0	-	-	-	-	-	-
26-27	15	1,164	388	224	294	[2,070]	[131,422]
27-28	24	8,900	15,143	395	335	[24,773]	[1,431,163]
28-29	17	835	979	1,984	326	[4,124]	[255,086]
29-30	24	399	288	649	421	1,757	108,401
30-31	24	1,433	1,376	2,186	379	5,374	332,746
5/31-6/1	24	568	2,361	1,162	156	4,247	244,025
1-2	21	6,186	2,554	1,519	663	10,922	693,614
2-3	7	-	-	1,014	85	1,099	70,755
3-4	0	-	-	-	-	-	-
4-5	0	-	-	-	-	-	-
5-63/	24	(19,507)	71,454	(24,693)	92,484	208,138	11,866,770
6-73/	6	(6,684)	24,484	(2,177)	8,155	41,500	2,316,220
7-8	0	-	-	-	-	-	-
Total	246	105,543	195,423	110,722	179,266	273,037	15,632,531

1/ Counts include expansions for non-functioning transducers and water velocity differences but no interpolations for missed time. Estimates of outmigrating smolt include expansions for unsonified areas between array.

2/ Validity of counts for 5/21-5/29 is questionable. Numbers in brackets are not included in totals.

3/ Offshore arrays operational, Inshore counts estimated on the basis of offshore counts and historical data.

-8-

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1975 NAKNEK RIVER SOCKEYE SALMON SMOLT STUDIES

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INTRODUCTION

This was the twentieth year that the Naknek River sockeye salmon (Oncorhynchus nerka) smolt study has been conducted. The objective of this program is to obtain an estimate of the size and age composition of the sockeye salmon smolt outmigration in the Naknek River.

MATERIALS AND METHODS

The materials and methods for data collection and analysis of age composition, lengths and weight, and general environmental data were the same as in previous years (McCurdy, 1972, 1973, 1974).

RESULTS

Table 1 contains all mean water and air temperature data gathered during the outmigration.

The random schedule was initiated on May 28 and terminated on July 9. The total random catch was 60,233 (Table 2) Seventy-three percent of the catch occurred between June 6 and June 13. Several minor peaks occurred throughout the season. A total of 126,678 smolt were caught during the index portion of the program (Table 3) During the random sampling hours, 2100-0600, the index net caught 41.08 percent of the total 24-hour catch.

The outmigration estimate for 1975 was 9,188,154 smolt. The estimate was obtained as follows:

1. Calculate the seasonal average random catch per 90 minute set:

   Total season catch = 60,233
   No. of sites fished = 6

   No. of sampling days fished during the season = 28

   Therefore, the seasonal average catch per 90 minute set is derived by
   60,233 / (6) (28) = 359

Table 1. Mean water and air temperatures by day, Naknek River, 1975.1/

Date		Mean water temperatures °F	Mean air temperatures °F
May	28-29	39.0	40.0
	29-30	40.2	39.0
	31-June 1	40.3	41.0
	1-2	44.5	38.5
	3-4	43.8	41.0
	4-5	47.0	36.5
	6-7	38.3	43.2
	7-8	45.9	44.2
	9-10	42.0	35.7
	10-11	52.2	39.9
	12-13	51.4	41.9
	13-14	53.2	44.6
	15-16	51.4	43.2
	16-17	50.0	43.9
	18-19	50.0	42.6
	19-20	50.7	42.8
	21-22	52.0	49.6
	22-23	49.3	42.8
	24-25	45.1	44.1
	25-26	46.0	42.6
	27-28	53.2	52.0
	28-29	50.7	51.4
	30-July 1	50.2	46.2
	1-2	50.2	43.3
	3-4	50.5	47.7
	5-6	55.8	47.3
	7-8	54.1	45.5
	8-9	55.2	52.5

1/ Both water and air temperatures were recorded for each 90-minute fishing period.

Table 2. Naknek River random sampling catches of sockeye salmon smolt by fishing site, 1975.

Date	Sites 1	2	3	4	5	6	Total	Percentage of total catch
May 28-29	1	25	12	4	14	0	56	0.09
29-30	1	0	2	4	0	1	8	0.01
31-June 1	2	1	126	0	12	12	153	0.25
1-2	12	0	0	47	325	563	947	1.57
3-4	17	650	0	103	0	120	890	1.48
4-5	65	471	180	103	13	143	975	1.62
6-7	1,031	280	3,168	10	1,214	162	5,865	9.74
7-8	745	10,266	4,198	782	176	1,196	17,363	28.83
9-10	484	1,745	924	855	1,718	32	5,758	9.56
10-11	0	1,167	836	190	65	369	2,627	4.36
12-13	448	884	4,345	3,925	2,280	318	12,200	20.26
13-14	4	116	0	0	38	2	160	0.27
15-16	3	2	46	384	0	0	435	0.72
16-17	364	74	115	1,258	3	37	1,851	3.07
18-19	0	3	149	3	100	48	303	0.50
19-20	85	57	113	68	134	0	457	0.76
21-22	48	125	455	32	48	116	824	1.37
22-23	0	131	5	945	195	488	1,764	2.93
24-25	43	123	102	0	87	30	385	0.64
25-26	106	0	32	8	55	11	212	0.35
27-28	0	7	624	432	0	5	1,068	1.77
28-29	0	35	29	188	144	0	396	0.66
30-July 1	147	1	0	294	8	25	475	0.79
1-2	16	0	752	1,635	17	0	2,420	4.02
3-4	200	196	65	1,150	33	225	1,869	3.10
5-6	0	222	6	351	28	8	615	1.02
7-8	0	63	2	30	0	16	111	0.18
8-9	0	0	0	0	22	24	46	0.08
Total	3,822	16,644	16,286	12,801	6,729	3,951	60,233	
Percent	6.35	27.63	27.04	21.25	11.17	6.56	100.0	100.0

Table 3. Naknek River index net catches of sockeye salmon smolt by 90-minute periods, May 29-July 9, 1975.

Time	May 29-30	June 1-2	June 4-5	June 7-8	June 10-11	June 13-14	June 16-17	June 19-20	June 22-23	June 25-26	June 28-29	July 1-2	July 5-6	July 8-9	Total	% of Total Catch
2100-2230	1	1	87	328	288	147	224	295	240	19	77	1	108	0	1,816	1.43
2230-2400	4	3	404	1,871	570	301	384	670	945	91	188	423	351	0	6,205	4.90
0000-0130	5	45	90	782	532	240	1,258	402	1,220	137	240	1,635	400	210	7,196	5.68
0130-0300	4	60	65	2,606	228	48	146	172	1,026	25	98	611	47	47	5,183	4.09
0300-0430	4	1,022	132	16,259	2,028	0	315	78	0	6	3	338	63	0	20,248	15.98
0430-0600	4	1,048	101	8,198	891	0	432	38	0	0	138	545	1	0	11,396	9.00
0600-0730	1	21	160	8,424	350	17	275	0	65	0	28	0	0	0	9,341	7.37
0730-0900	1	61	204	5,236	370	85	522	6	0	0	26	0	0	0	6,511	5.14
0900-1030	0	3	110	1,007	540	833	33	8	0	0	51	0	0	0	2,585	2.04
1030-1200	0	0	1,672	1,019	2,490	1,344	164	2	83	3	0	0	0	0	6,777	5.35
1200-1330	0	0	1,628	344	1,027	1,232	196	9	0	0	109	0	0	0	4,545	3.59
1330-1500	0	1	656	205	799	1,757	2	27	28	0	32	0	0	0	3,507	2.77
1500-1630	0	0	4,215	1,481	414	1,385	282	21	12	1	14	0	0	0	7,824	6.18
1630-1800	0	2	4,815	9,532	1,408	1,128	878	158	0	0	275	0	20	0	18,216	14.38
1800-1930	0	0	1,337	6,979	32	574	184	0	0	0	69	0	0	0	9,175	7.24
1930-2100	0	3	2,036	2,792	245	220	360	0	17	0	480	0	0	0	6,153	4.86
Totals	24	2,270	17,712	67,063	12,212	9,311	5,655	1,885	3,636	282	1,828	3,553	990	257	126,678	100.00

2. Estimate the average migration past the sampled section of the river during a 90 minute period within a sampling period.

Average catch per 90-minute period = 359
No. sites fished = 6
No. of subsites for which the migration is estimated from the catch at each fishing site = 6

Therefore the estimated average migration past the sampled section of the river during a 90-minute period within a sampling period is derived by

(359) (6) (6) = 12,924

3. Estimate the average migration past the sampled section of the river per sampling period.

No. of 90-minute periods within a sampling period = 6

Therefore, the estimated average migration past the sampled section of the river per sampling period is derived by:

(12,924) (6) = 77,544

4. Estimate the average migration past the entire width of the river at the sampling location per sampling period.

Estimated proportion of migration occurring within the section of the river presently sampled = 88.34 percent.

Therefore, the estimated average migration past the entire width of the river at the sampling location per sampling period is derived by:

77,544/ .8834 = 87,779

5. Estimate the average daily migration past the sampling location.

Estimate proportion of daily migration occurring during the sampling period derived by adding the percentages of the total season's index net catch for the hours 2100-0600 = 41.08 percent.

Therefore the estimated average daily outmigration past the sampling location is derived by:

87,779/ .4108 = 213,678

6. Estimate the total seasonal migration past the sampling location.

No. of days fished = 43

Therefore the estimated total seasonal migration past the sampling location is derived by:

(213,678) (43) = 9,188,154

The age composition of the outmigration estimate was 48.04 percent Age I smolt (4,413,989), 51.92 percent Age II smolt (4,770,490) and 0.04 percent Age III smolt (3,675). Table 4 gives the age composition by date.

A total of 1,037 smolt were sampled to determine lengths and weights by age class (Table 5 and 6). Age I smolt averaged 97.5 mm in length (20-year average = 101 mm) and 8.3 g. in weight (20-year average = 9.4 g.). Age II smolt averaged 110.7 mm in length (20-year average = 113 mm) and 12.1 g. in weight (20-year average = 12.6 g.).

Table 4. Age composition of the random sampling catches of sockeye salmon smolt, by date, Naknek River, 1975.

Date	Random Catch	Percent			Number		
		Age I	Age II	Age III	Age I	Age II	Age III
May 28-29	56	9.5	90.5	0.0	5	51	0
29-30	8	14.3	85.7	0.0	1	7	0
31-June 1	153	6.3	93.7	0.0	10	143	0
1-2	947	16.7	83.3	0.0	158	789	0
3-4	890	12.5	87.5	0.0	111	779	0
4-5	975	60.0	40.0	0.0	585	390	0
6-7	5,865	57.5	42.5	0.0	3,372	2,493	0
7-8	17,363	32.5	67.5	0.0	5,643	11,720	0
9-10	5,758	55.0	45.0	0.0	3,167	2,591	0
10-11	2,627	51.3	48.7	0.0	1,348	1,279	0
12-13	12,200	52.5	47.5	0.0	6,405	5,795	0
13-14	160	47.5	52.5	0.0	76	84	0
15-16	435	40.0	57.5	2.5	174	250	11
16-17	1,851	37.5	62.5	0.0	694	1,157	0
18-19	303	77.5	22.5	0.0	235	68	0
19-20	457	72.5	25.0	2.5	331	114	12
21-22	824	72.5	27.5	0.0	597	227	0
22-23	1,764	82.5	17.5	0.0	1,455	309	0
24-25	385	57.5	42.5	0.0	221	164	0
25-26	212	75.0	25.0	0.0	159	53	0
27-28	1,068	47.5	52.5	0.0	507	561	0
28-29	396	72.5	27.5	0.0	287	109	0
30-July 1	475	50.0	50.0	0.0	238	237	0
1-2	2,420	52.5	47.5	0.0	1,270	1,150	0
3-4	1,869	77.5	22.5	0.0	1,448	421	0
5-6	615	57.5	42.5	0.0	354	261	0
7-8	111	50.0	50.0	0.0	56	55	0
8-9	46	65.0	35.0	0.0	30	16	0
Total	60,233				28,937	31,273	23
Percent					48.04	51.92	0.04

Table 5. Naknek River sockeye salmon smolt mean weight in grams, 1975.

Date	Age I		Age II		Age III	
	Percent of total season's catch	Mean weight	Percent of total season's catch	Mean weight	Percent of total season's catch	Mean weight
May 28-29	0.02	9.8	0.16	15.7	0.00	----
29-30	0.00	10.4	0.02	15.1	0.00	----
31-June 1	0.03	12.6	0.46	20.1	0.00	----
1-2	0.55	12.3	2.52	18.7	0.00	----
3-4	0.38	13.4	2.49	15.2	0.00	----
4-5	2.02	9.5	1.25	12.5	0.00	----
6-7	11.65	9.8	7.97	14.9	0.00	----
7-8	19.50	8.7	37.48	9.0	0.00	----
9-10	10.95	7.8	8.28	10.9	0.00	----
10-11	4.66	8.3	4.09	11.9	0.00	----
12-13	22.14	7.3	18.53	10.0	0.00	----
13-14	0.26	7.7	0.27	8.8	0.00	----
15-16	0.60	8.7	0.80	10.8	50.00	8.6
16-17	2.40	9.0	3.70	9.3	0.00	----
18-19	0.81	6.8	0.22	9.9	0.00	----
19-20	1.15	6.6	0.36	11.4	50.00	14.3
21-22	2.07	7.1	0.73	10.0	0.00	----
22-23	5.03	7.0	0.99	11.5	0.00	----
24-25	0.77	7.9	0.52	12.2	0.00	----
25-26	0.55	8.1	0.17	10.0	0.00	----
27-28	1.75	10.0	1.79	11.2	0.00	----
28-29	0.99	7.9	0.35	8.7	0.00	----
30-July 1	0.82	7.8	0.76	9.4	0.00	----
1-2	4.39	9.1	3.68	9.9	0.00	----
3-4	5.00	7.8	1.35	11.3	0.00	----
5-6	1.22	9.6	0.83	10.4	0.00	----
7-8	0.19	9.6	0.18	9.7	0.00	----
8-9	0.10	10.0	0.05	9.1	0.00	----
	Age I mean weight = 8.3		Age II mean weight = 12.1		Age III mean weight =11.5	

Table 6. Naknek River sockeye salmon smolt mean length in millimeters, 1975.

Date	Age I: Percent of total season's catch	Age I: Mean length	Age II: Percent of total season's catch	Age II: Mean length	Age III: Percent of total season's catch	Age III: Mean length
May 28-29	0.02	103.5	0.16	122.0	0.00	----
29-30	0.00	99.3	0.02	118.1	0.00	----
31-June 1	0.03	107.0	0.46	130.3	0.00	----
1-2	0.55	108.3	2.52	131.0	0.00	----
3-4	0.38	115.6	2.49	121.9	0.00	----
4-5	2.02	103.7	1.25	114.6	0.00	----
6-7	11.65	105.5	7.97	121.8	0.00	----
7-8	19.50	100.1	37.48	100.5	0.00	----
9-10	10.95	95.3	8.28	105.9	0.00	----
10-11	4.66	97.7	4.09	108.8	0.00	----
12-13	22.14	92.9	18.53	103.0	0.00	----
13-14	0.26	95.8	0.27	100.3	0.00	----
15-16	0.60	99.9	0.80	106.0	50.00	99.0
16-17	2.40	99.8	3.70	101.4	0.00	----
18-19	0.81	92.6	0.22	106.0	0.00	----
19-20	1.15	92.2	0.36	109.4	50.00	118.0
21-22	2.07	92.3	0.73	104.0	0.00	----
22-23	5.03	92.5	0.99	108.4	0.00	----
24-25	0.77	96.7	0.52	114.7	0.00	----
25-26	0.55	96.5	0.17	108.9	0.00	----
27-28	1.75	104.5	1.79	109.3	0.00	----
28-29	0.99	96.0	0.35	99.9	0.00	----
30-July 1	0.82	96.5	0.76	103.0	0.00	----
1-2	4.39	101.4	3.68	102.2	0.00	----
3-4	5.00	96.0	1.35	108.2	0.00	----
5-6	1.22	103.7	0.83	105.5	0.00	----
7-8	0.19	102.2	0.18	102.2	0.00	----
8-9	0.10	104.2	0.05	101.3	0.00	----

Age I mean length = 97.5   Age II mean length = 110.7   Age III mean length = 108.5

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1975 UGASHIK RIVER SOCKEYE SALMON SMOLT STUDIES

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INTRODUCTION

In 1955, the U.S. Bureau of Commercial Fisheries initiated a program of enumeration and sampling sockeye salmon (Oncorhynchus nerka) smolt at the outlet of the Ugashik Lakes system, Bristol Bay. This program was continued in 1956 and 1957 by the Fisheries Research Institute of the University of Washington. During this time, the primary purpose of the study was to provide an annual estimate of relative abundance of smolt migrating to sea by fishing an index sampling scheme using winged fyke nets. The U.S. Bureau of Commercial Fisheries acquired the Ugashik smolt program in 1958 and continued the studies through 1962. The sampling method was modified in 1958 by adding a random sampling scheme which provided a means of estimating the total smolt outmigration (Nelson, 1965; Nelson and Jaenicke, 1965).

The Alaska Department of Fish and Game assumed responsibility for the Ugashik smolt project in 1963 and has run it annually since then, except 1966 and 1971. The sample site has been changed slightly and some recent modifications have been made in the sampling methods (Schroeder, 1972 and Schroeder, 1974). In 1974, the random scheme was discontinued and only the index sampling scheme was run. The smolt sampling site was moved 280 feet upstream in 1974 (Schroeder, 1975).

The data obtained from this program have been used to estimate the total sockeye salmon smolt outmigration from the Ugashik Lakes, and to determine age composition, average lengths and weights. These data are used to estimate the optimum escapement ranges and to forecast numbers and age composition of returning adults.

In this report Age I and Age II are defined as smolt that have spent one and two years, respectively, in freshwater prior to emigration.

MATERIALS AND METHODS

The 1975 Ugashik smolt project was to be based on the 3 hour index and 24-hour sampling schemes and computation formula as described in Schroeder (1973). In addition to the single fyke net, one 1970 model Bendix sonar smolt counter was placed just upstream of the fyke net. It was hoped that, eventually, use of fyke nets could be discontinued and that a total outmigration estimate could be obtained on the basis of sonar counts and the statistical relationship between sonar data and fyke net catches. Detailed descriptions of the 1970 sonar unit can be be found in Paulus and Parker (1974). The fyke net sampling procedure is described in Nelson (1965).

Bottom profiles and standard measurements of river velocity and discharge were made during the course of the season, climatological observations were made twice daily, at 0800 and 2000 hours, throughout the season.

Smolt samples were collected from fyke net catches for determination of mean weight, length and age composition of the outmigration.

RESULTS

Climatology and Hydrology

Climatological observations were taken from May 19 through June 13 and are shown in Table 1. The bottom contour measured at the index site is shown in Figure 1. Water velocity at the smolt site was 7.4 feet/second and discharge was 5,956 cubic feet/second. Both measurements were considerably higher than similar measurements recorded in 1974 (4.4 ft./sec. and 1,789 cu. ft./sec.) and 1973 (5.7 ft./sec. and 3,464 cu. ft./sec.). In addition, the increased depth made operation of the seven-foot fyke net extremely difficult. The current generated in the live box caused high mortalities to the captured smolt.

Sonar Sampling

The single sonar array malfunctioned soon after it was placed in the water as indicated by rapid and continual accumulation of counts unsubstantiated by fyke net catches. Before the unit could be repaired, ice outflow from the lake broke the sonar support cable damaging several transducers. Because of the continual presence of ice and the mechanical malfunction of the counter, the gear was not re-installed during the season.

Fyke Net Sampling

The index program began on May 22, but was curtailed after 1-1/2 hours of fishing due to heavy ice flows from the lake. These conditions persisted through June 3. Fishing was resumed on June 4, and continued through June 14.

The season's total catch for the 3-hour index scheme was 18,235 smolt. In addition, 3,379 smolt were captured during non-index hours of the two 24-hour index sampling schemes conducted (Tables 2 and 3). Due to the extremely limited time during which sampling was conducted, no estimate has been made of the numbers of smolt emigrating from the Ugashik Lakes in 1975.

Because of the discontinuous fyke net sampling, smolt collected for age, weight and length (AWL) analysis may not accurately represent the characteristics of the total outmigration. Smolt sampled were 25% Age I, 74% Age II and 1% Age III. Mean lengths were 95.8 mm, 115.7 mm and 125.0 mm, respectively. The mean weights for the three age groups were 7.2 g., 13.0 g. and 16.7 g. Smolt sampling data is listed in Table 4. The length frequency distribution is shown in Figure 2.

Table 1. Climatological observations, Ugashik River, May 19-June 13, 1975.

Date	Sky 0800	Sky 2000	Wind 1/ Direction 0800	Wind 1/ Velocity(mph.) 2000	Air Temp. °C. Max.	Air Temp. °C. Min.	Water Temp. °C. Max.	Water Temp. °C. Min.	24-hour Precip. (inches)	Turbity 0800
5/19	4	4	E 15	E 20	7.2	0.0	1.1	1.1	-	1
5/20	4	4	NW 15	NW 15	7.2	-2.2	1.1	1.1	.24	1
5/21	4	2	NW 15	NW 15	6.1	-2.2	1.7	0.8	.05	1
5/22	4	4	W 15	W 15	7.8	-1.7	1.1	1.1	.01	1
5/23	1	1	S 5	S 5	7.8	-2.2	3.3	1.1	T	1
5/24	4	4	SE 25	SE 25	2.8	-2.2	1.7	1.7	.07	1
5/25	3	3	SE 40	SE 40	7.2	-3.9	2.2	2.2	.22	1
5/26	4	4	SE 30	SE 30	7.2	1.7	2.2	2.2	.05	1
5/27	3	3	SE 30	SE 5	7.2	1.7	2.2	1.7	.04	1
5/28	3	2	NE 5	SE 5	7.2	1.7	2.2	2.2	.01	1
5/29	2	1	SE 5	SE 5	7.8	0.6	2.2	2.2	0	1
5/30	1	1	SE 5	SE 5	8.9	0.0	4.4	2.2	0	1
5/31	3	3	SE 10	SE 10	8.9	2.8	3.3	3.3	.10	1
6/1	3	1	SE 10	SE 10	12.2	3.3	3.3	3.3	.02	1
6/2	1	1	-	-	12.8	3.3	3.3	3.3	T	1
6/3	3	3	SE 5	S 5	12.2	2.7	3.3	2.8	0	1
6/4	4	4	SW 15	SW 5	-	-	-	-	T	1
6/5	4	4	SW 5	SW 5	5.6	1.1	2.5	2.2	T	1
6/6	4	4	SE 5	0	7.8	1.1	2.2	2.2	.14	1
6/7	4	2	SE 5	SE 10	7.8	2.2	3.3	2.2	.02	1
6/8	3	3	E 20	E 25	8.9	3.9	4.4	3.3	.08	1
6/9	4	3	E 5	E 5	13.9	5.0	5.6	3.3	.28	1
6/10	2	1	SE 5	SE 10	12.2	6.1	5.6	5.0	0	1
6/11	2	2	SE 5	SE 15	11.7	3.9	6.1	5.0	0	1
6/12	4	3	SE 5	SE 5	11.1	5.0	6.1	6.1	.02	1
6/13	3	3	SE 5	SE 5	14.4	3.9	6.1	6.1	0	1

1/ Wind velocities were taken with a Dwyer wind gauge which is inaccurate at velocities over 10 m.p.h.

Sky Codes: 1 = Clear sky, cloud covering not more than 1/10. 2 = Cloud covering not more than 1/2 of sky.
2 = Cloud covering more than 1/2 of sky. 4 = Complete overcast.
Turbity Code: 1 = clear

Figure 1. Bottom contour at smolt site Ugashik River, 1975.

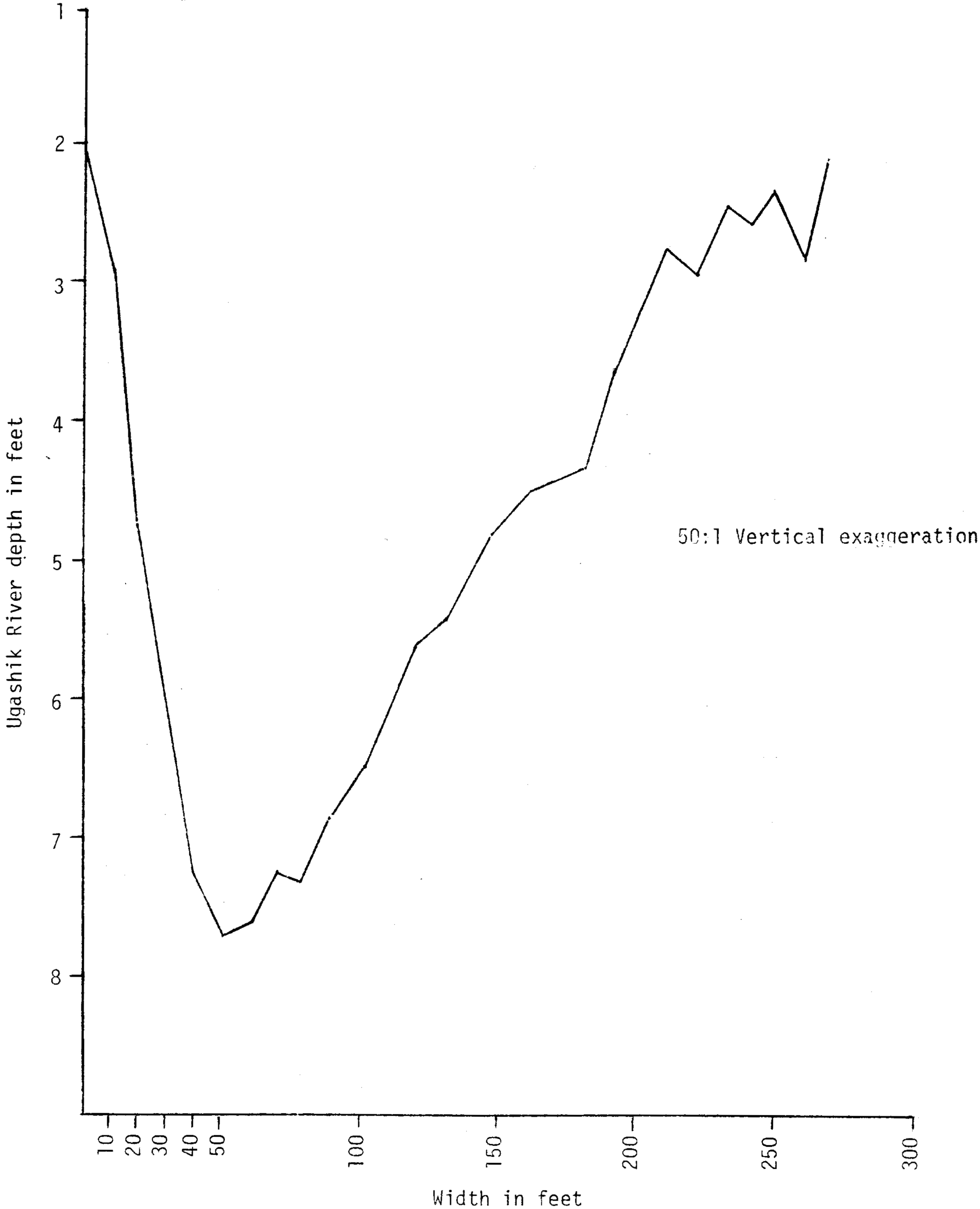

Table 2. Ugashik River sockeye salmon smolt three-hour index catch, by date and hour, 1975.

Date	Index Hours			Total Index Catch	
	2200-2300	2300-2400	2400-0100	Daily	Accum.
5/22	1	0	-	1	1
6/4	188	259	-	447	448
6/5	180	162	15	357	805
6/6	1,445	3,189	355	4,989	5,794
6/7	0	4	4	8	5,802
6/8	0	0	2	2	5,804
6/9	1,600	387	552	2,539	8,343
6/10	2,176	1,672	2,474	6,322	14,665
6/11	34	1	2	37	14,702
6/12	127	3	12	142	14,844
6/13	1,361	906	636	2,903	17,747
6/14	260	205	23	488	18,235
Totals	7,372	6,788	4,075	18,235	18,235

Table 3. Ugashik River sockeye salmon smolt index catch during 24-hour sampling periods, 1975.

Time Period	June 6-7	June 10-11	Total	Percent of Total
2200-2300	1,445	2,176	3,621	24.62
2300-2400	3,189	1,672	4,861	33.05
2400-0100	355	2,474	2,829	19.24
0100-0200	754	992	1,746	11.87
0200-0330	701	104	805	5.48
0330-0500	45	5	50	0.34
0500-0630	53	1	54	0.37
0630-0800	8	3	11	0.07
0800-0930	0	58	58	0.40
0930-1100	1	2	3	0.02
1100-1230	1	1	2	0.01
1230-1400	3	0	3	0.02
1400-1530	85	24	109	0.74
1530-1700	0	108	108	0.73
1700-1830	0	21	21	0.14
1830-2000	73	117	190	1.29
2000-2100	101	125	226	1.54
2100-2200	2	9	11	0.07
Totals	6,816	7,892	14,708	100.00

Table 4. Age, length, and weight of sockeye salmon smolt by daily sample from the Ugashik River, 1975.

Date	Mean Length (mm) Age Group			Mean Weight (grams) Age Group			Percent Age Composition		
	I	II	III	I	II	III	I	II	III
6/3	94.3	117.8	-	7.0	13.2	-	16	84	-
4	101.5	112.9	136.0	9.1	12.2	21.4	20	75	5
5	-	118.3	-	-	14.0	-	-	100	-
6	95.5	114.1	-	6.8	12.3	-	30	70	-
9	92.7	115.0	114.0	6.4	12.7	12.0	35	60	5
10	108.0	117.0	-	11.5	14.4	-	5	95	-
12	97.9	115.1	-	7.4	12.2	-	40	60	-
13	93.2	113.4	-	6.6	12.0	-	50	50	-
Weighted Averages	95.8	115.7	125.0	7.2	13.0	16.7	25	74	1

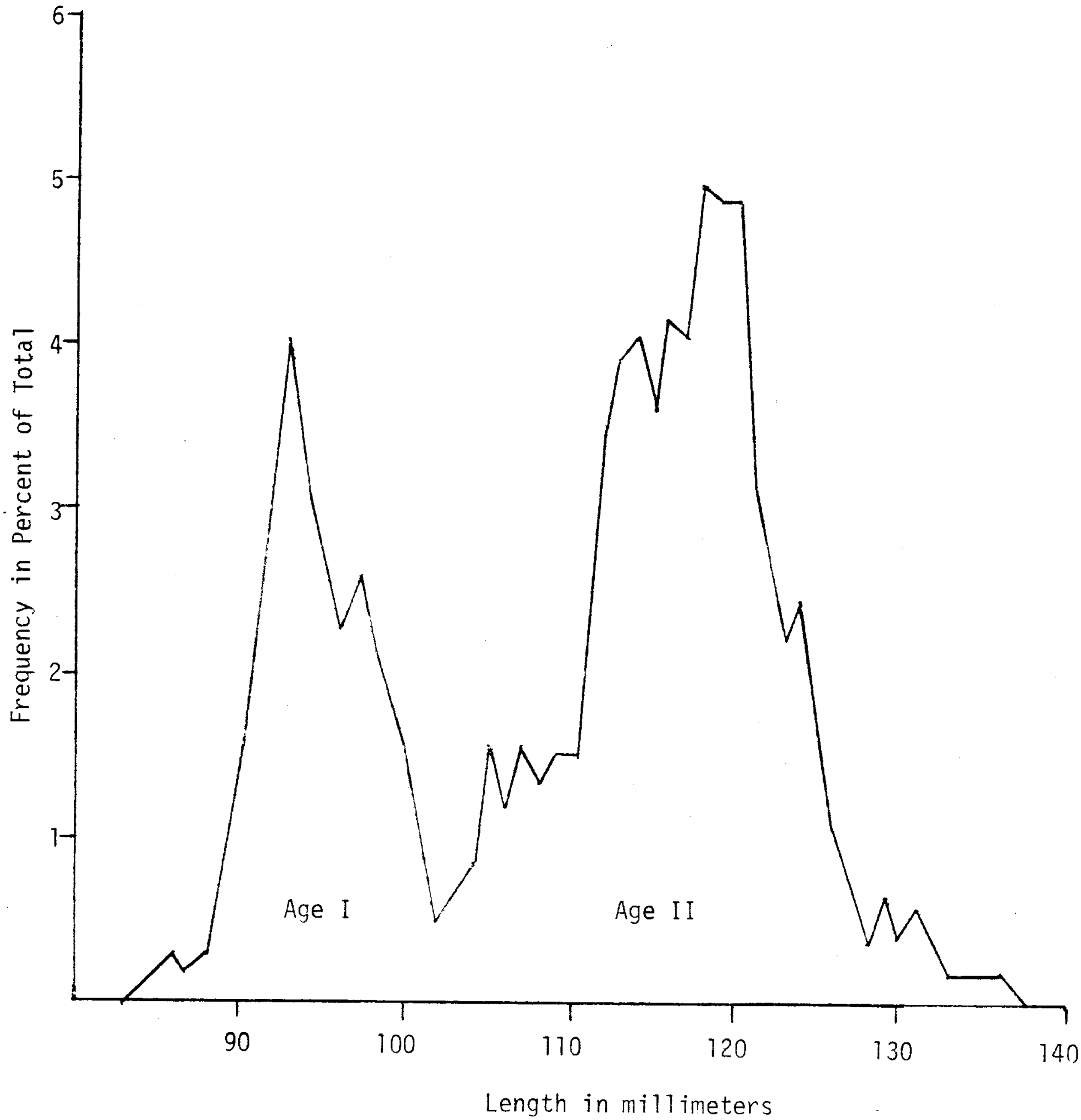

Figure 2. Unweighted length frequency of sockeye salmon smolt from the Ugashik River system, 1975. (frequencies smoothed by moving averages of three).

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1975 WOOD RIVER SOCKEYE SALMON SMOLT STUDIES

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INTRODUCTION

In 1951, the Fisheries Research Institute, University of Washington began a program to obtain an annual index of abundance of the sockeye salmon smolt outmigration from the Wood River lakes (Burgner and Koo, 1954; Koo, 1956). A standard winged fyke net was fished on a gravel shoal at Mosquito Point at the outlet of Lake Aleknagik (Figure 1), daily from 2100 to 2300 hours (Burgner, 1962). The Alaska Department of Fish and Game took over operation of the program in 1961 (Church, 1963; Church and Nelson, 1963; Nelson, 1964). In 1964, periodic 24-hour indices were added to the standard 2-hour index (Nelson, 1965). On the basis of distribution of catches during the 24-hour indices, frequent 5-hour indices (2200 to 0200) were added to the sampling schemes in 1965 (Nelson, 1966) and 1966 (Seidelman, 1967). The program was run in conjunction with a marking program being conducted by the Bureau of Commercial Fisheries in 1967 (Nelson, 1967), 1969 (Biwer, 1972) and 1970 (Schroeder, 1972). The Wood River smolt program provided information on abundance, growth and migration timing but the most important aspect, the statistical relationship between the magnitude of the parent escapement and the index of seaward migrants was found to be extremely variable and, therefore, of little value in forecasting future returns of adults.

In 1975, $600,000 appropriated by the Alaska Legislature was dedicated to begin rehabilitating sockeye salmon production in the Wood River Lakes. The component projects include investigations of methods of suppression of Arctic char predation on sockeye smolt, pathological investigations of parasitism of sockeye smolt by *Triaenophorus crassus*, distribution and abundance of northern pike (*Esox lucius*), the definitive host for *T. crassus* and utilization of Arctic char and pike in the sport fishery. To adequately evaluate the management options based on the results of these projects, it was deemed necessary to determine a total outmigration estimate of smolt emigrating from the Wood River system. Estimates of consumption of smolt by char could then be related to the magnitude of the outmigration to better assess the impact of this predation. In addition, eventual return of adult salmon will yield quantitative information on smolt survival in the marine environment. This would provide data which can be used to reach general conclusion regarding the impact of char predation in terms of loss of future spawners and loss to the commercial fishery.

Beginning in 1970, the Bendix Corporation, Electrodynamics Division, applying the technology derived from development of adult salmon sonar counters, produced a smolt counter for use in a total outmigration program on the Kvichak River. The 1975 Wood River smolt program incorporated the most recent version of the Bendix biomass counters designed by Mr. Al Menin.

The specific objectives of the 1975 Wood River smolt project were:

(1) Obtain a total outmigration estimate of smolt from the Wood River system using the new sonar equipment

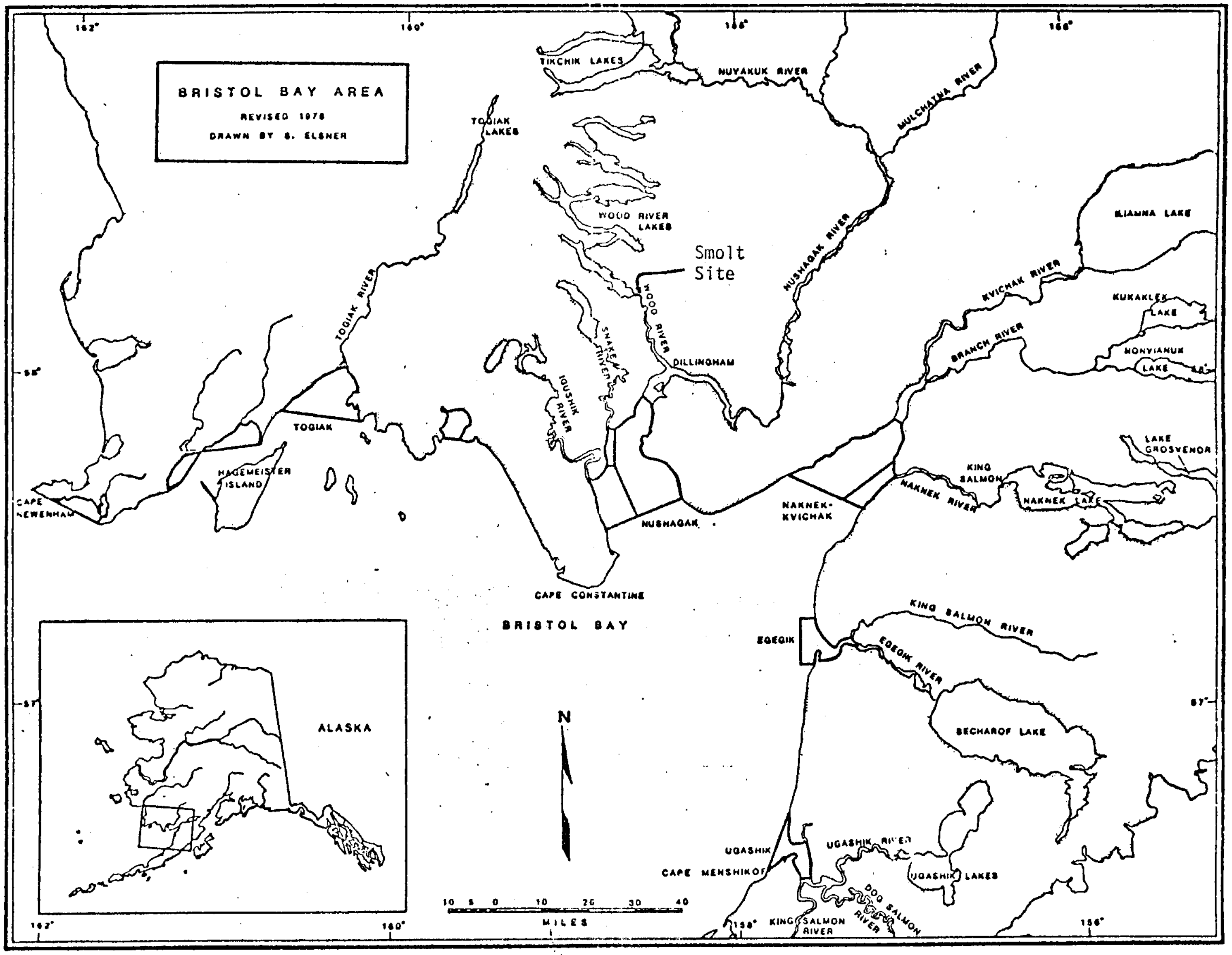

Figure 1. The Bristol Bay area, Alaska, showing the location of the Wood River Smolt project.

(2) Estimate age composition, length, weight, incidence of parasitism by T. crassus and timing of the smolt outmigration.

MATERIALS AND METHODS

The 1975 Wood River smolt project utilized the most recently developed Bendix smolt sonar system. The system utilized twenty transducers, ten on each of the two 11-foot arrays. The arrays are constructed of PVC plastic pipe in a ladder-like arrangement similar to the gear used on the Kvichak and Ugashik Rivers except that all transducers are aimed upward (Paulus and Parker, 1974). The arrays are attached by a 75 foot length of rope to 150 pound yachtsman anchors secured in the river bottom. The main rails of the array are equipped with one-way valves and hose connectors and can be flooded with water or pumped dry to raise or sink them. The transducers are connected to the electronic control unit by 350 feet of cable.

The sonar electronics contain resettable digital totalizers for each array, a printer which registers accumulated counts are preselected time intervals and a bank of twenty light-emitting diodes (LED's), which correspond to specific transducers. The electronics contain two depth range controls for each array so that even on a relatively uneven bottom, the array can be leveled electronically. A disable switch on the panel face allows disconnect of both the printer and digital counters without interupting the timer. This enables the operator to avoid prolonged false counts caused by boat passage or similar disturbances in the water without shutting down the entire system.

The electronic circuitry of the sonar counter is designed to evaluate the echo return received by the transducers. Electronic compensation is automatically made for reduction of echo strength due to target distance. The electronics are designed to register one count for the biomass equivalent of five smolt.

The equipment was installed in the Wood River at the north (left) bank tower site approximately 1-1/2 miles downstream from Mosquito Point. The inshore array was located 50 feet from the bank and the offshore array was 110 feet from the bank. The electronics, sheltered in a wall tent, were manned by a technician at all times. The tape output from the sonar counter gave cumulative counts per 15 minute period. Adjustments for "false counts" due to boats, wind, ice, etc. and missed counting times were made hourly and recorded in the sonar log.

Since the entire Wood River is subject to tidal influences, it was expected that river velocity would fluctuate continually with the flood and ebb of the tide. The electronic control unit was set for a river velocity of 4.5 feet per second. Differences between this set velocity and the actual river velocity cause the electronics to undercount or overcount in direct proportion to the ratio of the velocity set on the electronics to the actual river velocity. In order to develop a statistical velocity model to estimate hourly velocities, and correct all hourly counts after the season, lake depths were recorded six times daily at the ADF&G cabin at Lake Aleknagik, river depth was recorded every 1/2 hour at the sonar site as the arrays were electronically adjusted for rising or falling water level. Over the course of the season, 66 velocity measurements were made at a depth of 12 inches behind the inshore array using a pygmy gurley meter. A velocity profile for the Wood River was made using a type AA gurley meter. The adjusted counts were "corrected" for hourly river velocity changes. The "corrected" counts represent the total counts by hour taking into account all known sources of error.

A new side-scanning sonar unit was utilized during much of the period of outmigration. This system consists of a single, narrow-beam (2°) transducer aimed laterally across the river. Output from the system could be recorded on tape cassettes, paper tape from a fathometer and could be connected to an oscilloscope for real time visual observation. Observations made from the side-scanner output were intended to aid in describing smolt distribution across the river. In order to expand total sonar counts to calculate an estimate of total outmigration, information on smolt distribution was necessary.

Daily samples of smolt were collected with a fry seine near the outlet of Lake Aleknagik. Sample days were from noon (1200 hours) to noon of the following day. A 0.5 kg sample was collected each night during the period 2200 to 0300 hours. Each smolt was measured for fork length and gross external observations were made for signs of parasitism by T. crassus. From each of these length frequency samples, a random subsample of twenty smolt was made for age-weight-length (AWL) data. Each fish in this subsample was measured for fork length, weighed to the nearest 0.1 gram and inspected for evidence of T. crassus. Scale smears were made for each of the smolt in the AWL samples. Mean length was determined by weighting mean lengths from each sample period by the number of sonar counts recorded during that period. Mean weight for each age group was calculated on the basis of length-weight regression ($W=aL^b$), and a correction factor to obtain an unbiased estimate of mean weight (Pienaar and Ricker, 1968).

RESULTS

Climatological Observations

Table 1 lists the weather observations taken at the Wood River ADF&G cabin from May 29 through July 19, 1976. Amount of preceipitation was not recorded due to inaccuracy of the rain gauge. Wind speed and direction were estimated. Maximum air temperatures should be regarded as approximations only, since the thermometer was located in a dark-colored enclosure which was exposed to direct sunlight on clear days. The water gauge was installed in a standard location and water depths are, therefore, comparable to data recorded at this site in previous years. Stream temperatures were taken six times daily at the sonar site. Mean daily water temperatures are shown in Table 2 and plotted in Figure 2.

Hydrology

Figure 3 shows the bottom contour and velocity profile for Wood River at the sonar site. Velocity readings for this profile were taken during a 2 hour period beginning 1 hour before low water.

A statistical velocity model was developed to provide data on hourly velocity changes necessary to correct sonar counts for the difference between the velocity set on the electronic controls and the actual river velocity. Throughout the season, 66 velocity readings were taken immediately downstream of the inshore array. Since the depth adjustments on the sonar were checked every 30 minutes, sufficient data was available to make an initial examination of the relationship of river depth to velocity. It was apparent that two components of depth were affecting river velocity: average daily river depth, and tide stage. The effects of increasing lake level and the resultant increase in mean daily river depth on velocity became especially apparent during mid-June.

Table 1. Weather observations, Wood River, 1975.

Date	Sky AM	Sky PM	Precipitation AM	Precipitation PM	Wind AM	Wind PM	Air Temp °F Max	Air Temp °F Min	Water Guage (inches)	Turbidity
5/29	4	4	0	A	--	--	64	36	----	1
30	2	3	0	A	E 1-5	NE 5-10	64	34	----	1
31	2	4	0	A	NE 10-15	NW 10-15	64	34	-9.4	1
6/1	4	2	A	0	NW 5-10	NW 5-10	66	36	-6.7	1
2	4	4	A	A	NW 5-10	NW 1-5	59	34	-4.2	1
3	3	2	A	0	NW 1-5	NW 1-5	--	38	-0.9	1
4	4	3	A	A	NE 1-5	NE 5-10	--	96	1.3	1
5	4	4	A	A	NE 1-5	NE 1-5	62	38	3.4	1
6	4	4	0	A	NE 1-5	NW 1-5	58	42	6.5	1
7	4	3	B	A	Calm	NE 1-5	64	40	9.0	1
8	4	2	A	0	NE 20-25	NE 20-25	--	36	10.4	1
9	4	3	A	A	NE 15-20	NE 5-10	56	42	11.3	1
10	3	3	A	A	NE 1-5	NE 1-5	--	38	13.1	1
11	3	2	A	A	NE 5-10	NE 15-20	--	43	15.0	1
12	2	2	0	0	NE 5-10	NE 5-10	--	36	15.9	1
13	1	1	0	0	NW 1-5	NW 1-5	--	43	17.7	1
14	4	1	A	0	NW 1-5	NW 1-5	70	39	18.5	1
15	2	1	A	0	NW 1-5	NW 1-5	--	38	19.7	1
16	4	4	0	A	Calm	NE 1-5	43	40	20.5	1
17	4	4	A	A	Calm	NE 1-5	--	38	21.1	1
18	4	4	A	A	NW 1-5	Calm	--	--	22.2	1
19	4	4	A	A	Calm	Calm	--	40	22.9	1
20	1	2	0	0	NE 1-5	NW 1-5	64	45	23.3	1
21	4	4	0	0	W 1-5	W 5-10	60	44	23.5	1
22	4	4	A	B	NW 5-10	W 5-10	50	42	23.3	1
23	4	4	A	A	W 5-10	NW 1-5	52	43	23.5	1

Sky Codes:
1 - Clear sky, cloud covering less than 10%
2 - Cloud covering not more than 50%
3 - Cloud covering more than 50%
4 - Completely overcast
5 - Fog or thick haze

Precipitation Codes:
A - Intermittent rain
B - Continuous rain
C - Snow
D - Snow and rain
E - Hail

Turbidity Codes:
1. Clear
2. Partly clouded
3. Heavily clouded
4. Debris

Table 1. (continued)

Date	Sky AM	Sky PM	Precipitation AM	Precipitation PM	Wind AM	Wind PM	Air Temp °F Max	Air Temp °F Min	Water Guage (inches)	Turbidity
6/24	4	4	A	B	W 5-10	W 5-10	66	40	23.4	1
25	4	4	0	0	W 10-15	W 1-5	56	38	22.5	1
26	4	1	0	A	E 1-5	E 1-5	60	37	22.2	1
27	5	3	A	0	Calm	Calm	61	49	21.3	1
28	4	4	B	B	E 15-20	E 20-40	61	49	21.2	1-3
29	4	3	A	A	Calm	E 10-15	58	48	22.0	1
30	4	4	A	A	Calm	Calm	51	43	22.8	1
7/1	4	4	0	0	Calm	Calm	62	43	22.8	1
2	3	3	0	0	Calm	Calm	66	44	21.6	1
3	3	3	0	0	E 10-20	E 5-10	64	48	20.6	1
4	3	3	0	0	E 10-20	E 10-20	60	48	19.8	1
5	4	2	0	0	Calm	Calm	72	48	18.8	1
6	3	3	0	0	E 10-15	E 15-20	68	42	17.8	2
7	4	3	0	0	Calm	Calm	65	47	16.6	1
8	4	3	0	0	Calm	Calm	72	38	15.5	1
9	2	2	0	0	Calm	Calm	--	47	14.2	1
10	3	4	0	B	Calm	E 15-20	65	58	13.4	1
11	4	2	B	0	Calm	Calm	68	50	13.8	1
12	4	4	0	B	E 1-5	E 5-10	68	45	12.9	1
13	5	4	A	B	Calm	Calm	62	44	12.8	1
14	4	4	0	A	Calm	S 1-5	0	0	11.8	1
15	3	1	0	0	SW 10-15	S 5-10	64	47	10.9	1
16	3	4	0	0	Calm	Calm	66	44	9.6	1
17	4	3	A	0	E 5-10	E 1-5	54	48	8.5	1
18	4	3	0	A	Calm	Calm	66	47	7.2	1
19	3	3	0	0	Calm	Calm	70	46	6.7	1

Sky Codes:
1 - Clear sky, cloud covering less than 10%
2 - Cloud covering not more than 50%
3 - Cloud covering more than 50%
4 - Completely overcast
5 - Fog or thick haze

Precipitation Codes:
A - Intermittent rain
B - Continuous rain
C - Snow
D - Snow and rain
E - Hail

Turbidity Codes:
1. Clear
2. Partly clouded
3. Heavily clouded
4. Debris

Table 2. Mean daily water temperatures recorded at sonar site, 1975.

Date	Mean Temp (°C)	Date	Mean Temp. (°C)
5/29	2.5	6/24	4.7
30	2.3	25	5.0
31	2.0	26	4.9
6/ 1	2.5	27	5.4
2	3.0	28	5.3
3	3.3	29	4.9
4	3.0	30	5.0
5	2.8	7/ 1	4.9
6	3.0	2	5.5
7	3.3	3	5.3
8	3.3	4	5.5
9	3.0	5	5.8
10	3.0	6	5.6
11	2.8	7	6.0
12	3.3	8	6.1
13	3.3	9	5.9
14	3.5	10	6.0
15	5.0	11	6.1
16	4.8	12	5.9
17	4.5	13	6.0
18	4.3	14	6.1
19	4.8	15	6.2
20	-	16	7.1
21	4.8	17	8.5
22	4.8	18	9.7
23	4.5	19	9.4

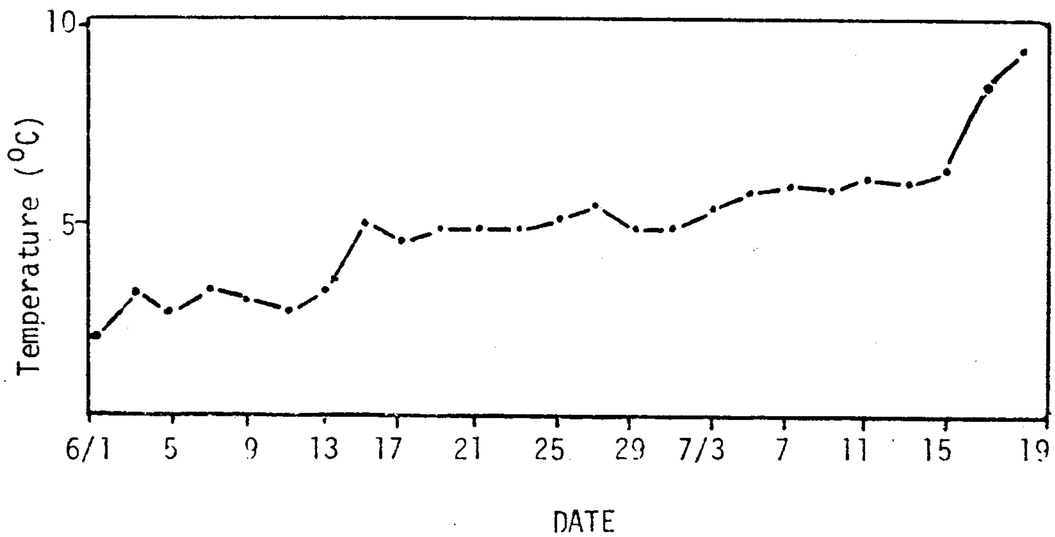

Figure 2. Mean daily water temperatures, Wood River sonar site, 1975.

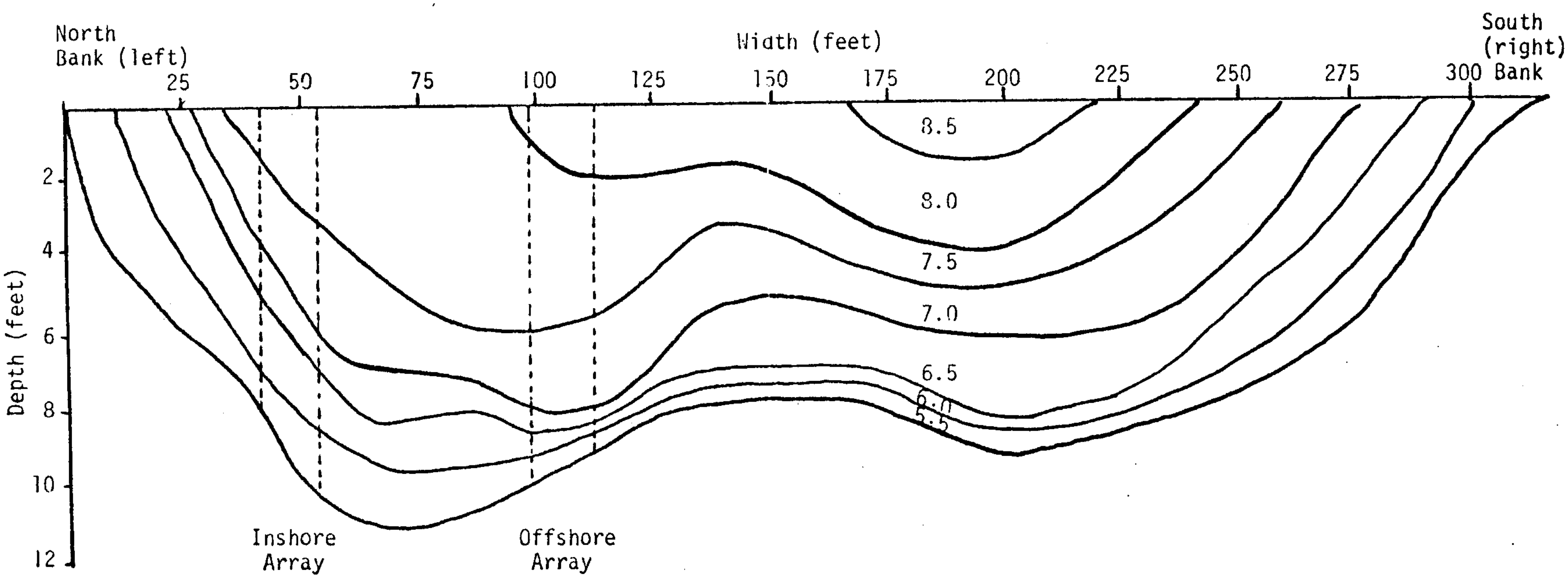

Figure 3. Bottom contour and velocity profile for the Wood River at the smolt site, 1975.

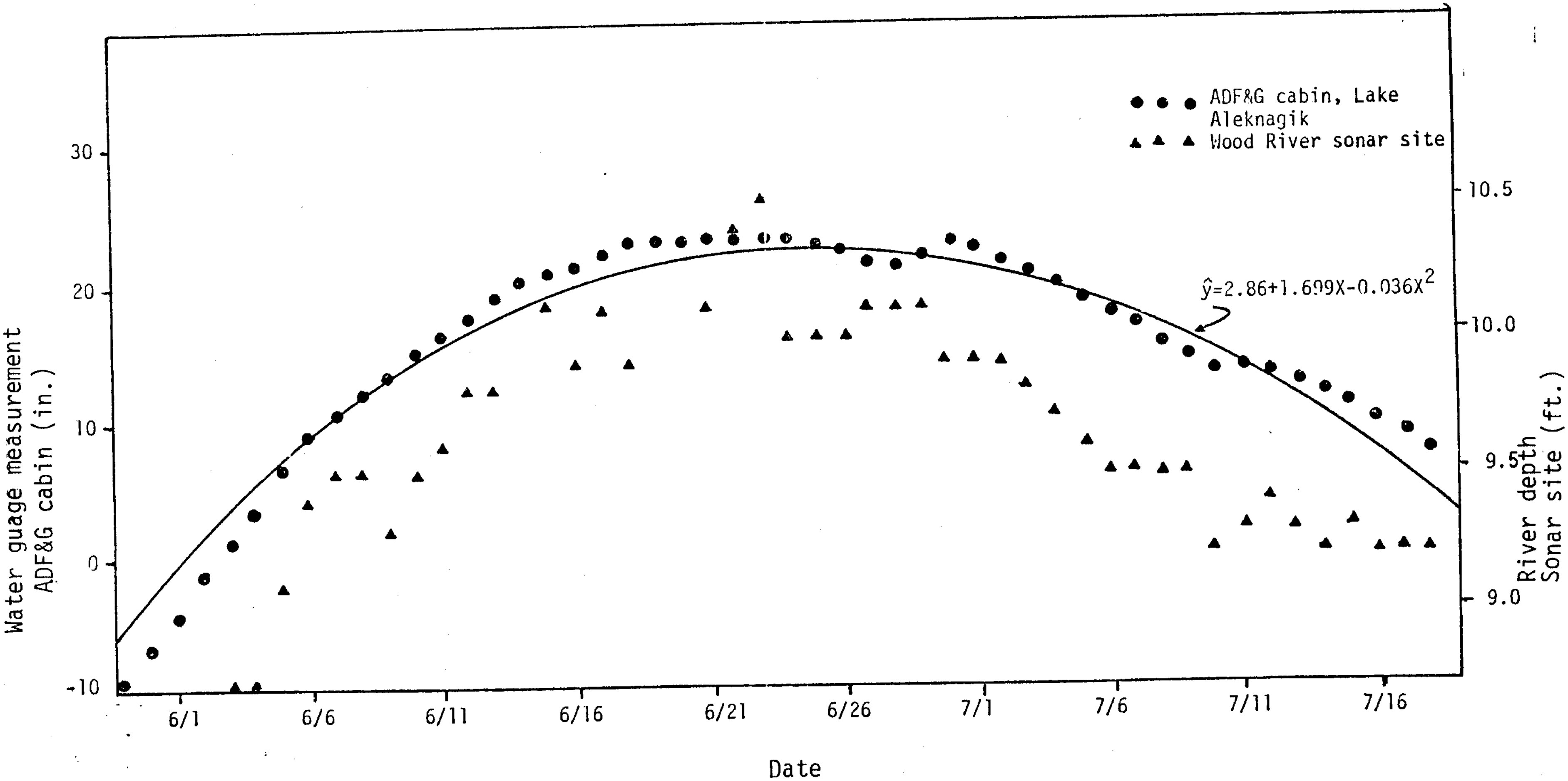

Figure 4. Mean daily water depth at the Lake Aleknagik ADF&G cabin and at the Wood River sonar site, 1975.

During this period, when the lake was at the highest levels, the highest tides (about 20 feet) failed to reverse the river flow, as they had earlier in the season.

Daily mean lake depth measurements recorded at the cabin varied in a smooth curvilinear manner. The first measurement, taken on May 31 was -9.4 inches. These measurements increased gradually to a high of 23.5 inches on June 23 and then receded to 6.7 inches on July 19. Tidal influence in the lake was in the range of $\pm$ 2-3 inches whereas tidal influences caused river depths to vary by several feet (Figure 4). The seasonal fluctuations in daily mean lake level can be described by the curve:

$$D_L = 2.860 + 1.699\ X_1 - 0.0357\ X_1^2 \qquad [1]$$

where D_L = daily mean depth of the lake, measured at the cabin
X_1 = time in days using June 3 = day 1.

Although daily mean river depth fluctuates more than lake level due to tidal fluctuations, it is apparent from Figure 4 that it closely follows the lake fluctuations. The relationship of mean daily river depth to mean daily lake depth is linear:

$$D_R = 8.633 + 0.062\ X_2 \qquad r=0.927,\ n = 44 \qquad [2]$$

where D_R = 2 daily mean depth of the river
X_2 = D_L = daily mean lake depth

By substituting the equation for D_L (formula 1) for X_2 in formula 2, an estimate of daily mean river depth (D_R) can be made, ignoring tidal influences, as a function of time in days.

$$D_R = 8.811 + 0.106\ X_1 + 0.002\ X_1^2 \qquad [3]$$

where X_1 = time in days using June 3 = day 1

From the surface settings in the sonar log, it was determined that the tidal fluctuations at the sonar site lagged approximately 2 hours behind the tidal stage at Clark's Point in Nushagak Bay. A multiple regression was calculated using the 66 velocity readings as the dependent variables and D_R and the tide (in feet) at Clark's Point two hours prior, as the independent variables. This yielded:

$$V_R = -2.578 + 0.805\ X_3 - 0.042\ X_4$$

$$r = 0.6032,\ n = 66,\ p < 0.01$$

where V_R = Estimated surface velocity at the inshore array
X_3 = D_R calculated in formula 3
X_4 = tide at Clark's Point two hours prior

An additional regression was calculated using dummy variables to code for direction of tidal movement (ebb or flood). This regression failed to improve the relationship appreciably. The hourly estimates of V_R were then used to correct the hourly sonar counts to compensate for differences between the velocity set on the electronics and the estimated river velocity.

Sonar Counting

The two sonar arrays were installed in the river on June 1. The sonar counter was operated from 2200 to 0300 (ADT), June 2 through June 11. On June 12, counting began on a 24-hour basis. A malfunctioning transmitter crystal caused the system to be inoperative from June 17-21. Once the crystal had been replaced, a 24-hour per day counting schedule was resumed until the project was terminated on July 19.

To estimate for the days missed while the counter was inoperative, the results of the nightly beach seine sampling were compared to the total daily counts recorded. Regression of beach seine CPUE (kg of smolt per haul) against total daily counts for the same day yielded the linear relationship:

$$Y = 15259.2 + 3519.2X$$

where X = daily beach seine CPUE
Y = estimated daily counts
$r = 0.5170$, $n = 30$ $p < 0.01$
$t_b = 3.138$ $p < 0.01$

This relationship was then used to estimate for the outmigration between June 17 and 21.

A total of 862,868 counts were recorded, 528,281 of these occurred during index hours. Daily counts and index hour counts and beach seine CPUE for the corrected counts are shown in Table 4 and Figure 5. Total index hour counts represented 61.2% of the total counts. The index hour counts varied from 13.1% to 91.7% of the total daily counts ($\bar{x} = 55.7 \pm 6.9\%$, $p < 0.05$). Of the season's total counts, 68.6% were recorded over the inshore array. Total daily counts over the inshore array exceeded the counts over the offshore array on 23 of the 34 days during which 24-hour counting was conducted. A nonparametric sign test indicated that, the distribution of fish as they crossed the array was not random ($p < 0.03$).

Side Scanning Sonar

The "side-scanner" was operated frequently throughout the outmigration. From the outset, it was apparent that the indicated distribution of smolt, as presented by the side-scanner electronics, differed considerably from that indicated by the bottom arrays. Frequently, heavy counts were observed over the inshore array while the side-scanner traced smolt schools further offshore with almost no indication of inshore schools. A large part of this variability can be explained by the volume of water sampled by the side scanner beam with increasing distance from the transducer. The center of the inshore array was 50 feet from shore. At that distance, the cross section of the cone-shaped beam would be only 20.9 inches, the volume of water sampled over the inshore array was 24.4 cubic feet. The offshore array, with its center 110 feet from shore, would have a cross-section of 46.1 inches and would insonify a volume of 109.5 cubic feet. Therefore, the probability of a school of smolt being recorded vary with its depth in the water and distance from the transducer. In addition, the number of times a school of smolt will present a target depends on the distance from the transducer (and, therefore, the size of the beam at that distance) and their depth. In other words a school swimming very near the surface will cause fewer echos than a similar size school at the same distance but deeper in the water.

The transducer for the side scanner was manually aimed across the river. By starting with the transducer aimed at the surface and moving it slowly downward, an attempt was made to achieve as much distance as possible and keep the beam just below the surface. However, the transducer mounts are not designed for fine control, and depth and angle were roughly set each time. Because of

Table 3. Index hour and total daily corrected sonar counts and beach seine CPUE (kg/haul), Wood River, 1975.

Date	Index counts (2200-0300 ADT) Inshore	Offshore	Total	Daily Total (1200-1200 ADT) Inshore	Offshore	Total	CPUE
June 3-4	653	60	713				
4-5	295	57	352				
5-6	181	49	230				
6-7	295	49	344				
7-8	1,272	193	1,465				
8-9	4,819	451	5,270				
9-10	687	49	736				0.097
10-11	1,191	1,138	2,329				0.153
11-12	7,562	1,473	9,035				1.000
12-13	4,034	1,119	5,153	8,797	1,930	10,727	0.012
13-14	6,776	5,740	12,516	25,912	10,491	36,403	0.125
14-15	26,421	3,506	29,927	61,584	7,399	68,983	2.500
15-16	9,011	5,718	14,729	14,731	8,403	23,134	2.000
16-17	574	1,771	2,345	1,977	2,890	4,867	0.002
17-18	-	-	(13,258)	-	-	(22,297)	2.000
18-19	-	-	(9,548)	-	-	(18,293)	0.862
19-20	-	-	(27,932)	-	-	(38,134)	6.500
20-21	-	-	(6,955)	-	-	(15,495)	0.067
21-22	992	1,190	2,182	3,385	2,948	6,333	0.010
22-23	784	3,586	4,370	2,386	5,343	7,729	0.083
23-24	3,724	6,372	10,096	6,002	10,642	16,644	0.090
24-25	2,306	5,476	7,782	5,345	8,991	14,336	3.300
25-26	9,229	3,440	12,669	11,486	6,119	17,605	0.730
26-27	3,521	5,654	9,175	8,381	8,161	16,542	3.800
27-28	4,234	4,992	9,226	5,626	6,085	11,711	0.500

Table 3. (continued)

Date	Index counts (2200-0300 ADT) Inshore	Offshore	Total	Daily Total (1200-1200 ADT) Inshore	Offshore	Total	CPUE
June 28-29	1,228	1,274	2,502	3,294	2,022	5,316	0.007
29-30	4,124	4,653	8,777	7,343	10,299	17,642	0.005
30-1	2,592	3,466	6,058	4,315	5,629	9,944	0.000
July 1-2	12,909	6,080	18,989	16,060	10,043	26,103	0.280
2-3	46,099	5,420	51,519	44,898	11,265	56,163	15.500
3-4	2,517	2,586	5,103	4,024	3,802	7,826	0.750
4-5	46,567	14,686	61,253	77,813	33,102	110,915	4.750
5-6	18,088	3,777	21,865	21,774	7,106	28,880	2.780
6-7	3,075	4,631	7,706	11,905	9,782	21,689	0.167
7-8	10,523	3,541	14,064	12,802	4,686	17,488	3.125
8-9	7,491	3,089	10,580	8,990	4,140	13,130	1.500
9-10	5,273	5,450	10,723	7,124	7,382	14,506	2.000
10-11	614	277	891	2,694	4,412	7,106	0.002
11-12	29,143	9,495	38,638	35,487	13,987	49,474	9.250
12-13	12,233	4,127	16,360	14,069	5,523	19,592	5.125
13-14	2,863	3,368	6,231	7,540	5,198	12,738	0.100
14-15	498	501	999	3,805	3,839	7,644	4.000
15-16	12,235	5,326	17,561	18,019	8,117	26,136	
16-17	2,649	4,815	7,464	15,339	14,997	30,336	
17-18	4,499	5,771	10,270	11,172	14,536	25,708	
18-19	1,319	1,394	2,713	3,983	3,704	7,687	
19-20	6,585	2,668	9,253	10,069	7,545	17,614	
Total	322,051	148,537	528,281 1/	498,131	270,518	862,868 2/	

1/ Includes 57,693 interpolated counts not included in in shore and off shore totals.
2/ Includes 94,219 interpolated counts not included in in shore and off shore totals.

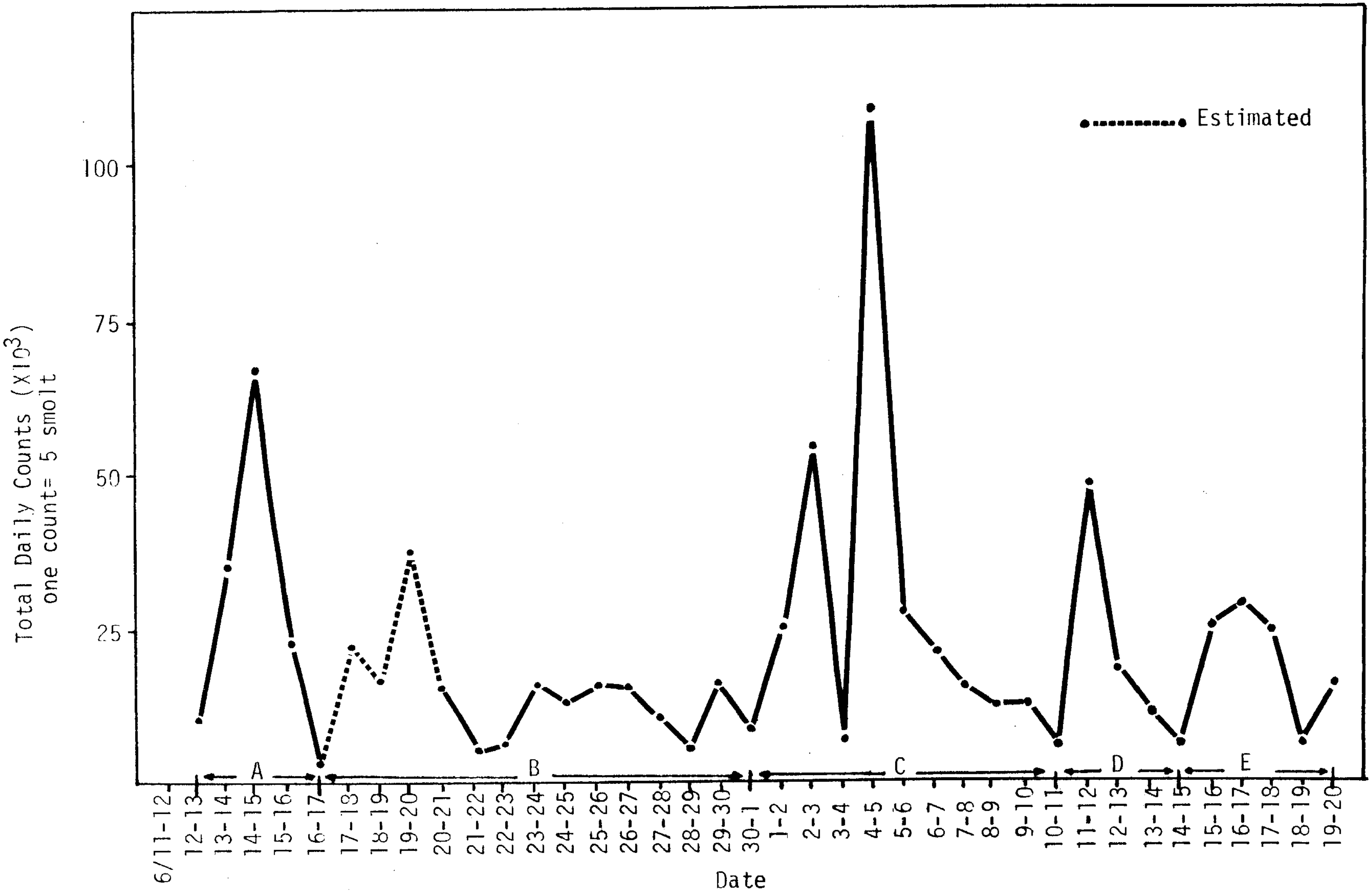

Figure 5. Total daily corrected counts of sockeye salmon smolt, Wood River, 1975.

the difficulty in setting the transducer, it was necessary to place it deeper in the water when the tide was ebbing to avoid having to reset it frequently. On a flood tide, the transducer was set as high as possible initially. Therefore, the distance from the surface to the sonified areas were not necessarily consistent from day to day, or from hour to hour. Visual observations made at night with a spotlight from a boat behind the arrays indicated that sometimes, at least, the smolt are distributed in the upper few inches of water and might not be accessible to the side scanning sonar. For these reasons, the side scanner data was not utilized to attempt to extrapolate numbers of fish counted over the arrays to estimate total fish passage.

Smolt Samples

During the period of the outmigration 2,346 smolt were measured for length (snout to fork of tail). Gross external observations for infection by *T. crassus* was made on all smolt. A total of 610 smolt were used for age-weight-length data.

Examination of the smolt scales collected showed a very high degree of overlap between the length distributions of the two age groups. Age I smolt ranged from 68 mm to 99 mm while age II smolt varied from 74 mm to 110 mm. Determination of length frequency and mean length for the outmigration was done using AWL samples divided into 5 millimeter length groups and an adaption of a method used by Vincent (1969). The AWL samples were divided into 5 mm length groups. The percent age I and age II were calculated for each length group (Table 5). All observations below 74 mm were age I. Similarly, all smolt larger than 99 mm were age II. The percent age composition for each length group in the overlap areas was then applied to similar length grouping of the length frequency samples. The resultant length frequency distribution is shown in Figure 6. Weighted mean length for age I smolt was 82.5 mm and for age II was 97.9 mm. Mean weight for age I smolt was 5.1 g. and age II was 10.1 grams.

Occurrence of *T. crassus* in age I smolt examined was 59.9%. Age II smolt examined showed an infection rate of 47.7%. Figure 7 shows the length frequency distributions for smolt showing external evidence of *T.crassus* and those without evidence of parasitism. Length frequency distributions of smolt infected by *T. crassus* is similar to non-infected smolt; indicating that *T. crassus* may not have a deleterious effect on sockeye smolt growth.

Outmigration Estimate

Major peaks in daily counts (Figure 5) demonstrate a pattern similar to that found during the earlier fyke net programs. It was believed that the major peaks in daily outmigration may correspond, generally, to populations of smolt from different lakes. Since "break-up" occurs at Lake Aleknagek first, it is probable that the first peak is composed primarily of smolt from this lake. Break-up is progressively later from the upper lakes and, in addition, travel time for smolt from nursery lake to the smolt site is undoubtedly proportional to the distance traveled. This phenomenon would probably cause temporal isolation of populations of smolt from the various lakes. Emigration prior to break-up is considered to be inconsequential.

In attempting to allocate numbers of outmigrant smolt to their lake origin, the distribution of total daily counts was examined. The first peak, assumed to be smolt from Lake Aleknagek began June 12-13 and increased to its maximum on

Table 4. Sockeye salmon smolt age composition by length group from AWL samples, Wood River, 1975.

Length (mm)	Age I No.	Age I Percent	Age II No.	Age II Percent	Total
65-69	1	100	0	0	1
70-74	22	100	0	0	22
75-79	132	99.2	1	0.8	133
80-84	217	98.2	4	1.8	221
85-89	121	94.5	7	5.5	128
90-94	29	61.7	18	38.3	47
95-99	4	22.2	14	77.8	18
100-104	0	0	15	100	15
105-109			9	100	9
110-114			10	100	10
115-119			3	100	3
120-124			3		3
125-129			0		0
130			1	100	1
Total	526		85		

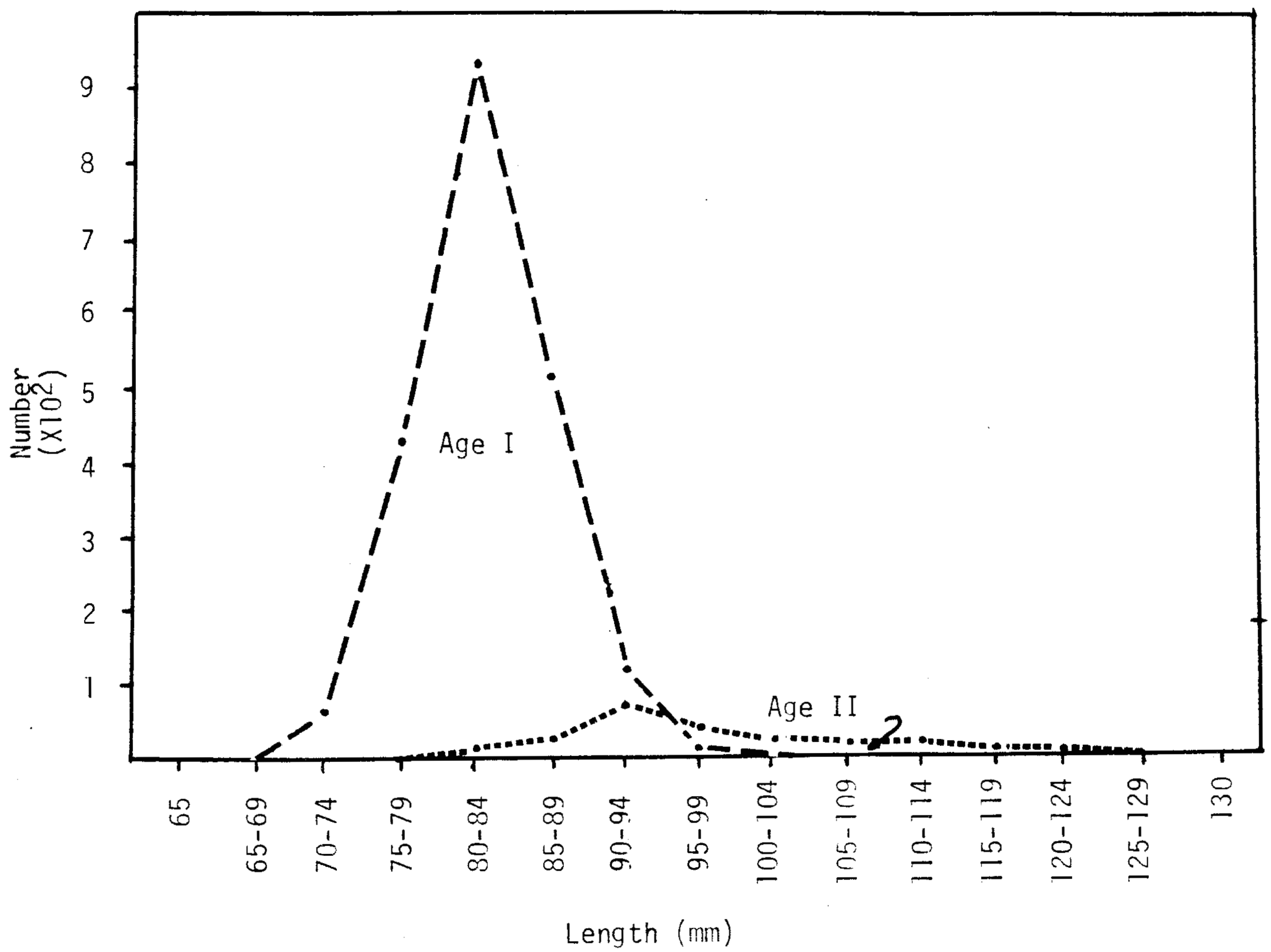

Figure 6. Length frequency distribution by 5 mm length groups, Wood River smolt, 1975.

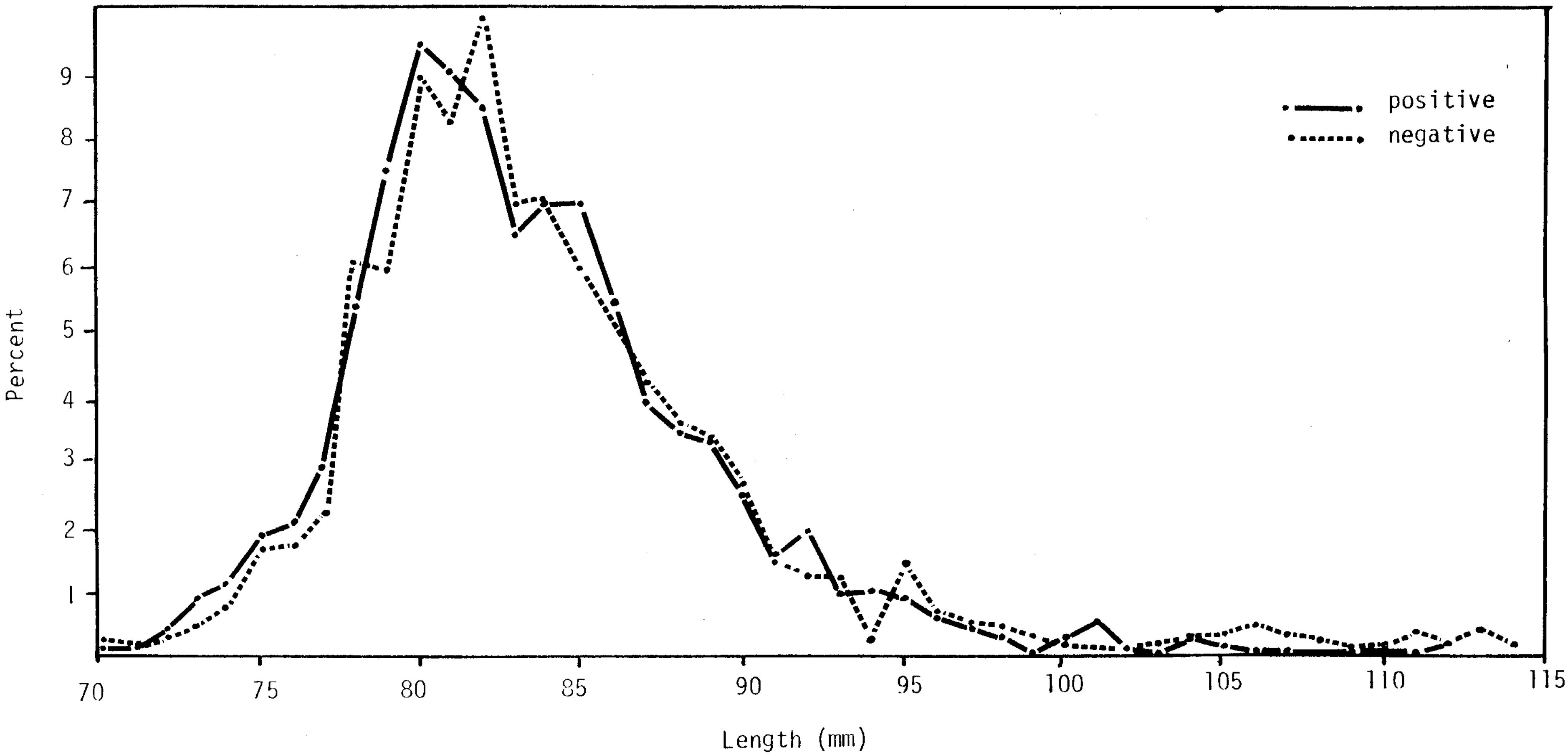

Figure 7. Length frequency distribution and indication of parasitism by Triaenophorus crassus, Wood River smolt, 1975.

June 14-15. The numbers of smolt counted decreased progressively until June 16-17 (group A). The second group (B) was composed of several smaller peaks occurring between June 17-18 and June 30-July 1. On July 1-2, daily counts increased greatly, reaching 56,163 on July 2-3. Although the counts dropped sharply on July 3-4, they did so for 1 day only, rising on July 4-5 to 110,915 counts. The counts then decreased gradually through July 10-11. This period (July 1-11) has been called group C. The pattern of rapid increase followed by a decrease over more than a single day was repeated for group D July 11-15 and group E (July 15-19) smolt.

Several characteristics of these component groups of migrating smolt were examined to try to statistically distinguish differences between the groups. Occurrence of T. crassus was essentially identical for all lakes (Table 6). The number of Age II smolt did increase through time, perhaps due to older fish from the upper lakes. Although there are some differences in the length distribution of Age II smolt, this may be a result of the small sample sizes of this age group. The length distribution curves for Age I smolt from groups A through D are essentially identical.

Rogers (1975) summarized fry abundance in the Wood River lakes. Rogers did not collect data from Beverly and Kulik and divided Nerka into three sections based on tow net results. Summing population estimates by Rogers for 1974 Age 0 and Age I fry in Lake Aleknagik yields 10.96 million fry. Table 5 gives the daily counts attributed to Lake Aleknagik (group A) as 144,114. Lake Nerka (B+C) accounted for 331,825 counts. Rogers' data from townetting indicated that Nerka had 22% more fry than Lake Aleknagik whereas the pattern of smolt outmigration indicated that group B (Nerka) contained 2.3 times as many smolt as group A (Aleknagik). Although pattern of smolt outmigration indicates that separate lake systems may be distinguished, there is at present no supporting data. Future work with smolt scales sampled from the various lakes and computerized scale analysis equipment may provide a more accurate method of allocating smolt sampled at Wood River to lake or origin.

Side-scanner data did not provide quantitative information on smolt distribution across the river channel. However, it did indicate that few smolt occur in the southern 1/3 of the river channel.

The total daily counts for the period June 12 through July 20 were expanded by the five fish per count rate as designed into the sonar electronics. Therefore, the total number of smolt enumerated over the two arrays was 4,314,340. Each array sampled a distance of 11 feet across the river. If it is assumed that smolt passage occurred only in the northern 220 feet of river, then the sonar arrays sampled 10.0% of the river. Any attempt to expand the 4.3 million smolt enumerated over the arrays to account for the 90.0% of the river not sampled leads to outmigration estimates which are unrealistically high. The escapement to the Wood River lakes was 330,474 in 1973 and 430,602 in 1972. Population estimates of sockeye salmon fry in the Wood River lakes were 28.6 million Age 0 and 0.2 million Age I fry (Rogers, 1975). Statistical expansion of the number of smolt counted by the sonar gear would yield an estimate exceeding the 1974 fry population estimate.

As discussed above, the smolt distribution is not random across the river. The inshore array consistently enumerated more smolt than the offshore array. Pattern of smolt school distribution was observed to change uniformly during the course of at least two nights. In both cases, side scanner information early in the evening indicated heavy concentration of smolt inshore. As the night pro-

Table 5. 1975 Wood River smolt total daily counts, age composition and percent infestation by T. crassus by component lake system.

Group	(Lake)	Date	Total Daily counts	Percent of total	Percent Age I	Percent infected by T. crassus
A	(Aleknagik)	6/12-6/17	144,114	16.7	95.5	59.9
B	(Lower Nerka)	6/17-7/1	218,021	25.3	91.4	59.7
C	(Upper Nerka)	7/ 1-7/11	303,804	35.2	81.8	54.9
D	(Beverly)	7/11-7/15	89,448	10.4	80.7	60.6
E	(Kulik)	7/15-7/20	107,481	12.4	-	-

gressed the pattern moved gradually offshore to a point beyond the offshore array. Then gradually it shifted back toward the north shore. This shift could be the result of changing current patterns (surface velocity) due to tidal fluctuations. However, there is not sufficient data to explain this phenomenon. Although the arrays sampled less than 10% of the river, they apparently enumerated much more than 10% of the total outmigration. Future work at Wood River will emphasize determination of smolt distribution to allow statistical expansion of daily count data, and hence provide valid estimates of the total number of smolt produced.

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